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An Analysis of the Natural Vegetation of the Macmillan Pass / Sheldon Lake area of the east-central Yukon Territory

University — Université
University of Alberta

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée
MSc

Year this degree conferred — Année d'obtention de ce grade
1984

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An Analysis of the Natural Vegetation of the Macmillan Pass / Sheldon Lake Area of the East-central Yukon Territory

by

Christine N. Boyd

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

Department of Forest Science

EDMONTON, ALBERTA

Fall 1984

THE UNIVERSITY OF ALBERTA

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Date 29 June 1984

Abstract

Impending mineral development of the Macmillan Pass/Sheldon Lake region prompted the Yukon Government to undertake a biophysical inventory of the area. A major objective was to map soils, surficial geology and vegetation. The data collected for use in the vegetation component of this inventory are presented and discussed in this thesis. The objectives were to 1) classify and 2) describe the vegetation communities of the area, and 3) postulate on which environmental factors control the distribution of these communities.

Four hundred and fifty-four sites, located in ca. 13,000 km^2, were surveyed for floristic composition, species cover and physical site properties. To aid in analysis the data set was divided into three ecological zones: 1) forested, 2) non-forested subalpine and alpine, and 3) non-forested below treeline. Each zone was analyzed separately. Sites were classified using complete-linkage cluster analysis. Sites and species were ordinated using detrended correspondence analysis (DECORANA). Site position along the ordination axes was correlated with environmental variables to determine major controlling environmental factors.

Twenty-eight community types (CT) and 42 tentative community types (TCT) were recognized: 9 CT's and 21 TCT's in the alpine/nonforested subalpine zone; 12 CT's and 9 TCT's in the forest zone; and 7 CT's and 12 TCT's in the below-treeline, non-forested zone. Soil moisture appeared to be the major controlling environmental factor in both of the non-forested zones, while soil pH and nutrient status appeared to be the major controlling factors in the forested zone.

Acknowledgements

A number of organizations have made this thesis possible. The Yukon Department of Renewable Resources allowed me to use the data which was collected by myself and others as part of a large Resource Inventory Project. I would like to acknowledge the financial assistance provided by the Youth Job Core Program, through the Yukon Conservation Society, which allowed for the hiring of summer field assistants. The Department of Forestry, University of Alberta and the Boreal Institue provided computing funds for the costly procedure of multivariate analysis.

There are numerous people who assisted with the field work and whom I wish to thank; Catherine Kennedy (Vegetation Technician), Karen McKenna (Soils Technician), Steve Morison (Surficial Geologist), Rosanna White and Laurel Duquette (Summer Assistants), Kerry Guenter and Mike Duff (Helicopter Pilots), and the many others who made life at Dewhurst Creek what it was.

During the data reformatting and analysis Chuck Humphrey, Computing Services, provided invaluable assistance. I can not thank him enough for his work and patience. I would like to thank Kerry Guenter for his comments during the writing of the thesis, for editing the first draft, and for his excellent drafting of the figures.

I would like to thank the members of my committee. I particularily appreciate the encouragement and criticisms offered by Drs. Ken Higginbotham and George La Roi.

This thesis is dedicated to Kerry, who tolerated my long absences from home, and who encouraged and supported me throughout my graduate studies.

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1. Introduction

The data used in this thesis were collected for use in a biophysical inventory program undertaken by the Department of Renewable Resources, Government of the Yukon, under the auspices of the Canada-Yukon Territorial Subsidiary Agreement on Renewable Resource Development. This agreement, signed in April 1979 by the federal departments of Indian and Northern Development (DIAND) and Regional and Economic Expansion (DREE), and the Yukon Territorial Government, allowed these parties to finance and initiate programs that would expand the resource information base to aid in the planning of social and economic development and the management of the territory's natural resources. Implementation of these projects was the responsibility of the Yukon Government (Davies et. al. 1983).

Program I of the subsidiary agreement, entitled "Renewable Resource Information and Analysis" was intended to provide information pertaining to renewable resources located in high priority areas of the territory. High priority areas were indentified by the Program I Subcommittee which determined that comprehensive resource inventories should be carried out in such areas. The inventory was to provide standardized resource baseline maps at a scale of 1:100,000 to be utilized in the preparation of regional plans.

The Macmillan Pass/Sheldon Lake region was recognized as a high priority area, mainly because of its high potential for mineral development. The decision to inventory the area was made during the spring of 1981 when there was much mineral exploration activity in the area. Amax Northwest Mining Company Ltd. was, and still is, considering development of a tungsten deposit (MacTung), located on the border between the Yukon and the Northwest Territories (Amax 1978). Two other promising properties for potential mineral development were the Jason property, then owned by Pan Ocean Oil, and the Tom property, owned by Hudson Bay Exploration. These are lead-zinc-silver properties situated close to Macmillan Pass along the Canol Road. There were, and still are, numerous other mineral claims staked, many of them by large mining concerns such as Union Carbide, Canada Tungsten, British Newfoundland, Cominco Ltd., and Noranda (Claim ownership maps, 1984).

The possibility of three operating mines, with associated mills, townsites, airstrips and roads, necessitated a resource inventory program. A resource inventory with surficial geology, soils, vegetation, aquatics and archeology components was carried out by the Department of Renewable Resources between June 15 and August 25, 1981. The author was responsible for planning and conducting the vegetation component of the inventory.

1.1 Statement of Objectives

The objectives of this study were 1) to classify and 2) describe the vegetation communities of the Macmillan Pass / Sheldon Lake area of the the Yukon Territory, and 3) to elucidate the major environmental factors controlling the distribution of these communities and their associated species.

2. Study Area

2.1 Location

The Macmillan Pass study area is located in the east-central Yukon, between 129° and 132° W longitude, and 62° 30′ and 63° 30′ N latitude (Fig. 1 and App. VII). It is bounded on the east by the Northwest Territories border, geographically the continental divide. It is approximately 13,000 km² in area. The North Canol Road, from Ross River, Y.T., to Norman Wells, N.W.T., bisects the study area from southwest to northeast. The road crosses the Yukon River-Mackenzie River divide at Macmillan Pass situated on the Yukon-Northwest Territories border. The area is relatively uninhabited at present except for a few mining camps, a highway maintenance camp near Sheldon Lake, a trapper's cabin at Dewhurst Creek, and a big game outfitter's camp on Keele Lake.

There are numerous small lakes in the study area. Niddery Lake drains into the Hess River; Dragon Lake into the Riddell River; Itsi Lakes, John Lake, Lewis Lake and Sheldon Lake into the Ross River; and Fuller Lake into the South Macmillan River.

2.2 Physiography

The study area encompasses parts of the Selwyn Mountain and Eastern Yukon Plateau physiographic units of Bostock (1965). Within the study area, the Selwyn Mountains are subdivided by the Ross River into the Hess Mountains to the north and the Logan Mountains to the south. The Eastern Yukon Plateau, which extends far into the Selwyn Mountains in the area between the Hess and Logan Mountains, is subdivided into the Macmillan and Pelly Plateaus roughly along the height-of-land between the Macmillan and Ross Rivers (Fig. 1).

Drainage is generally to the southwest into the Yukon River system, via the Hess, Macmillan, Ross, Pelly and Prevost Rivers. The terrain is characterized by high, rugged mountains rising to the continental divide in the northeast, but becomes more gentle and rolling in the plateau region towards the southwest corner of the study area. Maximum relief ranges from 850 m elevation ASL in the southwestern valley bottoms to 2952 m at the summit of Keele Peak in the north-eastern corner.

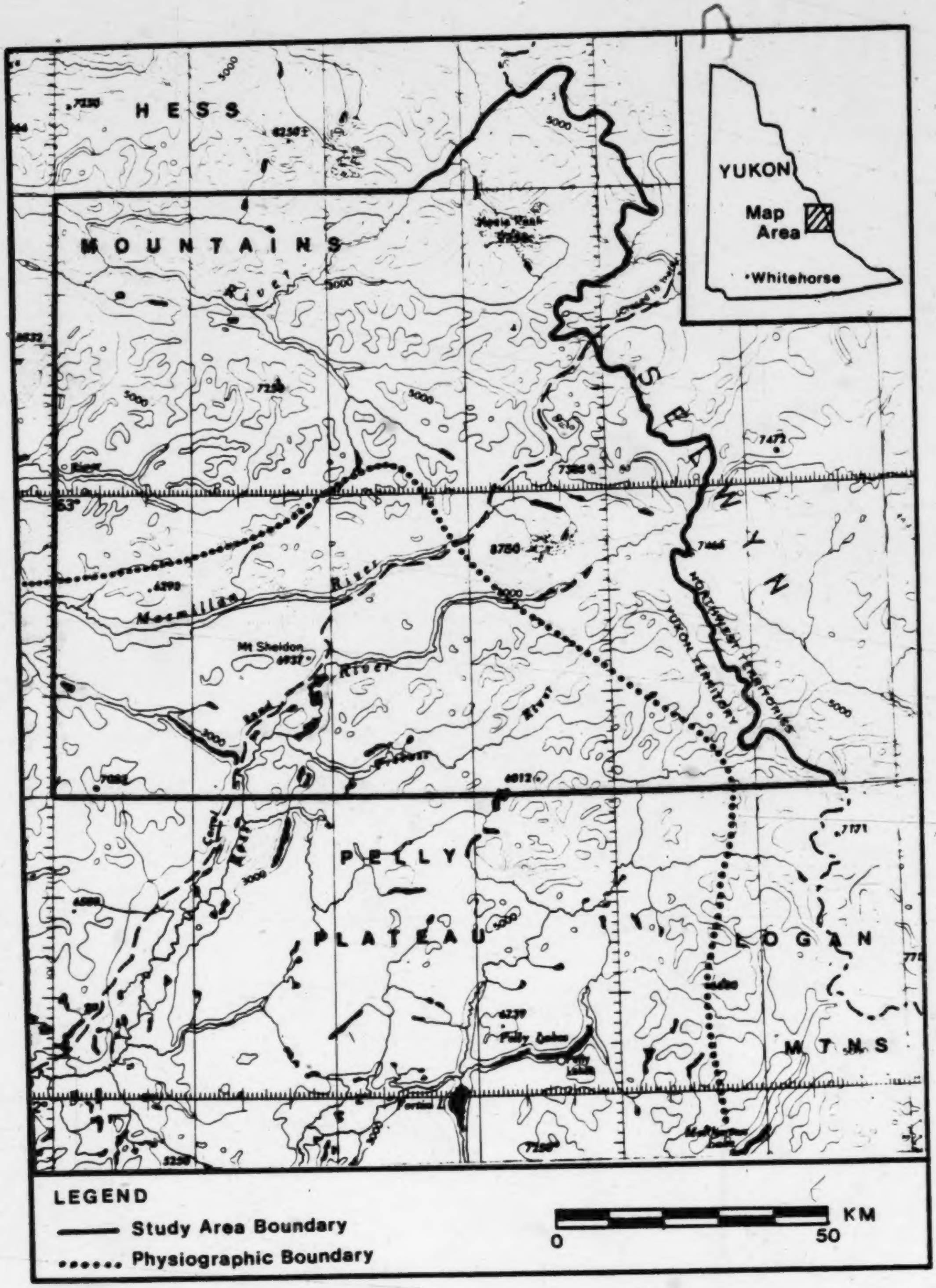
HESS
MOUNTAINS
SELWYN
PELLY
PLATEAU
LOGAN
MTNS
YUKON
Map Area
•Whitehorse
Macmillan River
Mt Sheldon
River
Pelly Lakes
NORTHWEST TERRITORIES
YUKON TERRITORY
5000
3000
63°
LEGEND
Study Area Boundary
Physiographic Boundary
KM
0
50

Figure 1. Macmillan Pass / Sheldon Lake study area location. Two major physiographic regions occur in the study area: the Eastern Yukon Plateau region, represented by the Pelly Plateau; and the Selwyn Mtn. region, represented by the Hess and Logan Mtns.

2.3 Geology

The geology of the study area is very complex, with Paleozoic shale and chert predominating (Abbott, pers. com.) [1]. In the extreme northeast corner near Keele Peak and in the southwest corner Proterozoic sedimentary and minor volcanic strata are evident. Cretaceous granite intrusions are common and form the major peaks such as Mt. Sheldon, Keele Peak, and the Itsi Range. Along the eastern edge of the study area near the Northwest Territories border, dolomite and limestone, more typical of the Mackenzie Mountains, may be found. These result in basic soils atypical of the rest of the study area (Abbot pers.com.). Quaternary unconsolidated glacial and alluvial deposits blanket the major valleys to ca. 1000 m (Roddick and Green 1961).

The plateau portion of the study area is mostly drift-covered and underlain with two major bedrock types: Paleozoic chert and shale in the north, central and east of the plateau; and older Proterozoic shale and slate south of the South Macmillan River and west of 131° W longitude. The latter area contains a discontinuous band of crystalline limestone located between the South Macmillan and Riddell Rivers. Late Mesozoic granitic intrusions, composed mostly of granodiorite, are infrequently scattered throughout the plateau, notably at Mt. Sheldon. In the extreme southwest corner of the study area, more recent Cenozoic volcanic flows of andesite, dactite, and basalt overlie the deformed paleozoic strata (Roddick and Green 1961).

Except for barite, noted at several locations in the chert and shale north of the South Macmillan River, no known mineral deposits of economic importance are present in the plateau region (Roddick and Green 1961).

Bedrock types of the Selwyn Mountains are predominately Paleozoic shale, chert and argillite (Blusson 1971, Cecile 1982), also characteristic of the adjoining plateau. Proterozoic slate and phyllite are found in the Keele Peak region. From Macmillan Pass trending northwest across the Niddery Lake Map Sheet, bands of intermittent Devonian to Mississippian shale, siltstone, chert and chert-pebble conglomerate occur. Devonian faulting and subsequent folding near Macmillan Pass has produced a complex zone termed the "Macmillan Fold Belt" (Abbot 1982), which contains several bedded barite and lead-zinc-silver barite deposits, some of possible economic importance.

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[1] Abbott, Grant. Geologist, Indian and Northern Affairs, Whitehorse, Yukon

2.4 Surficial Geology

2.4.1 Glacial Features

The Macmillan Pass study area was extensively glaciated by the MacConnell advance during the late Wisconsinian. Ice flowed westward from the Selwyn Mountains in the form of valley glaciers (Hughes et.al. 1968, Bostock 1966). Glacial deposits are widespread at elevations of less than 1200 m, but erractics have been found as high as 1500 m in the western portion of the study area (McKenna 1983). Common terrain types resulting from the McConnell glaciation are glacial till, glacio-lacustrine deposits, and hummocky ice-contact deposits (Morison pers.com.)[2]

Two types of till occur, a silty-clay, grey till common in the northern half of the study area, and a silty-sand, brown till occurring southwest of Mt. Sheldon and occasionally overlying the grey till in the north (Morison pers.com., Mollard 1982). In the north, till covering the slopes is very thin, with numerous bedrock exposures. Till deposits are generally thicker south of the South Macmillan River (Oswald and Senyk 1977, McKenna 1983). Many of the morainal deposits have been reworked. On moist lower and midslopes seepage in the channels and rills has resulted in some sorting of the sand and silts. A thin and locally discontinuous surficial veneer of reworked loess, consisting of peat and organic silt, sometimes overlies the till (Mollard 1982).

Over ten meters of silty glacio-lacustrine deposits occur along the Hess River, a result of damming of the Hess and South Macmillan Rivers by ice and bedrock ridges during deglaciation (McKenna 1983). In addition, glacio-lacustrine clayey silt and fine sandy silt deposits occur in level basins along the Canol Road corridor (Mollard 1982).

A high proportion of the valley landforms found in the study area are ice-contact in origin. Characteristically the sands and gravels exhibit a hummocky, ridgy or kettled appearance. Common landforms include eskers, kames, kame terraces, kame deltas, eskers, and short eskerine ridges (Mollard 1982).

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[2] Morison, Stephen. Placer and Coal Geologist, Department of Indian and Northern Affairs, Government of Canada, Whitehorse, Yukon. Mr. Morison was employed by the Yukon Department of Renewable Resources and was responsible for planning and conducting the surficial geology portion of the resource inventory.

2.4.2 Post-Glacial Features

Other landscape features caused by more recent processes are colluvial slopes, rock glaciers, fluvial plains and organic terrain. Extensive physical weathering, especially by frost shattering, of the shale bedrock of most ridgetops has resulted in a colluvial mantle on virtually every inclined mountain side. This mantle, which characteristically occurs as a veneer or thin blanket, reflects the lithological composition of the underlying bedrock but often contains reworked loess and organic material as well (McKenna 1983, Mollard 1982).

Fluvial sediments along the floodplains of the rivers and larger creeks consist largely of sand, with greater and lesser amounts of gravel, silt, cobbles and boulders. Well-developed thermokarst terrain is characteristic of floodplains having a higher proportion of clay, silt and fine sand (Mollard 1982).

Organic deposits, represented mostly by fens, are found in nearly all poorly-drained areas that are typically either level or gently sloping. The fibric and mesic peat in these minerotrophic fens may exceed 350 cm in thickness (McKenna 1983).

2.4.3 Permafrost Features

The Macmillan Pass study area falls within the zone of widespread discontinuous permafrost (Brown 1967). High-ice permafrost is found near the surface of most mid and lower slopes and in thermokarsted silty lacustrine and alluvial deposits. Permafrost is probably present at depth under most high ridges, well-drained knobs and coarse and medium grained glacio-fluvial and morainal deposits (McKenna 1983).

Notable permafrost features are open system pingos situated on the lower slopes of mountains and valley sides, and ice-cored palsas in the valley bottoms. Strongly expressed thaw holes occur in thicker peatlands and give rise to peat plateaus with expanding collapse scar sides and degrading ice-rich peat plateau margins (Oswald and Senyk 1977, Mollard 1982).

Solifluction lobes and terraces are confined to places where a thin coarse waste covers sloping bedrock, and where slopes are wet during the hot part of the summer. Solifluction features are best expressed from 1300 to 1400 m (Mollard 1982).

At upper elevations, the more subdued terrain has well-developed stone nets and bare-center circles (Oswald and Senyk 1977).

2.5 Soils

Soil parent materials within the study area are derived from a variety of bedrock sources and may vary in conjuction with bedrock lithologies. Soils associated with the very common acid shales are very strongly to slightly acidic in reaction, while those associated with calcareous bedrock are moderately alkaline. Alluvial materials and unfrozen wetlands are typically neutral (McKenna 1983).

Brunisolic soils, the most common great group in the study area, occur on a wide range of medium- and coarse textured parent materials. Orthic Humo-Ferric Podzols are formed in well to rapidly drained, acidic, coarse-textured, glacio-fluvial, alluvial, morainal and colluvial deposits. Where the process of podzolization is not well developed, Eluviated Dystric Brunisols occur. Regosolic soils occur on alluvial floodplains and steep colluvial slopes where there is periodic deposition of new materials. Cryosolic soils occur when permafrost is present within one meter of the surface, or two meters if the soil is strongly cryoturbated. Gleysols and Organic soils occur on poorly-drained sites (McKenna 1983).

A volcanic ash layer is present in many soil profiles. Approximately 5 cm of ash, orginating from Mount Bona in the St. Elias Mountains some 1200 years BP, was deposited on the study area by prevailing west winds (Lerbekmo et.al. 1973). Since that time wind and colluvial redeposition has resulted in some areas with no ash, while others have up to 15 cm. The position of the ash layer in the soil profile varies. It often occurs just below a poorly developed LFH horizon, while in some organic soils it is buried beneath 30 cm of decomposed peat.

Soil subgroups present in the study area are listed in Appendix I.

2.6 Climate

The climate of the Yukon Territory is subarctic-continental, characterized by daily and seasonal temperature extremes, low humidity, and low to moderate, sporadic precipitation. Moist, mild Pacific air may occasionally intrude into the typically cool, dry air mass (Wahl n.d.)

The Yukon has been subdivided into broad climatological zones, which correspond to major topographic features. The study area is located with the Ogilvie-Mackenzie Mtn. zone (Wahl, n.d.) Long-term climatological information for this zone is limited. Data summaries are given in Appendix II for Sheldon Lake, located in the southwestern portion of the study area; Tsichu River Camp, located along the North Canol Road east of the continental divide; and the town of Ross River, which lies to the southwest of the study area in the arid Central Yukon Basin zone.

2.6.1 Precipitation

Ross River, situated in a valley immediately north of the Pelly Mountains is affected by a rain-shadow. Precipitation is low, ca. 260 mm annually. The rain-shadow effect appears to extend northward into the study area as far as Dragon Lake. Here the terrain begins to rise more sharply and steadily towards the massive barrier of the Selwyn and Mackenzie Mountains. Annual precipitation increases steadily eastward due to the forced rising of the air as it moves towards this barrier. Annual precipitation is ca. 530 mm at Sheldon Lake, and exceeds 600 mm along the southwestern slopes of the Selwyns. This latter amount is over 100% more than is recieved at Ross River. Tsichu River receives ca. 510 mm of precipitation annually, 300 mm as snow (Wahl n.d.) Climatological data are summarized in Table 1.

Snow cover may have a significant influence on vegetation (Jonasson 1981). The higher elevations of the Sheldon-Tsichu area have a longer snow season and a deeper snowpack. Tsichu generally has 35 cm of snow on the ground by the end of October, reaching a maximum near 80 cm in April. In contrast, Ross River has only a trace of snow on the ground at the end of October, reaching a maximum of only 40 cm at the end of February. This is reduced to only a trace of snow on the ground by late April. Snow avalanches are common in the spring, especially in the northeast corner of the study area.

Table 1. Summary of Weather Information for the warmest and coldest months of the year. Sheldon Lake is the only meteorological station in the study area. Ross River is located to the southwest, and Tsichu River to the east. Complete summaries are in Appendix II.

	JULY			JANUARY		YEARLY		
	Mean Daily Temp (˚C)	Extreme Min (˚C)	Mean Rainfall (cm)	Mean Daily Temp (˚C)	Snow on Ground at Month End (cm)	Mean Daily (˚C)	Mean Snowfall (cm)	Total Precip. (cm)
Ross River	13.1	-3.3	45.5	-29.3	34	-5.3	110	267
Sheldon Lakes	12.0	-2.8	60.2	--	--	--	--	--
Tsichu River	10.0	-5.0	53.9	-24.1	69	-7.7	301	508

Though there are no all-season meteorological stations in the study area, crude approximations of total annual precipitation can by made. In general, precipitation increases by 8% for every 100 m increase in elevation up to a maximum at the 1500 to 2000 m level, above which there is a slow decrease with increased elevation (Wahl unpubl).

2.6.2 Temperature

The Ross River area is susceptible to great temperature extremes (-59.4 to 33.3° C). However, temperature extremes become more moderate towards the east. Due to higher elevations, mean annual temperatures are lower at Tsichu River than at Ross River. It is significant, however, that the mean January temperature at Tsichu is -24.2° C, 5.2° warmer than at Ross River, and that summer temperatures in the Macmillan Pass-Tsichu area are 4 to 5° C cooler than at Ross River.

The vertical change in temperature, which results in differing temperatures at Ross River and Tsichu River (lapse rate) can be used to extrapolate temperatures to the study area. Between April and October the lapse rate for the study area is a decrease in temperature of 6 to 7° C per 1000 m increase in elevation. During the winter a reversal of lapse rate occurs. As day lengths decrease, cold air develops over all surfaces, but tends to drain off the mountain slopes into the valley bottoms (Wahl unpubl.).

This reversal of lapse rate, termed thermal inversion, is dramatically evident in the study area. Temperatures on the valley floors range from -20 to -30° C, but increase at a rate of 3 to 5° C per 1000 m to temperatures near -10 to -15° C at the 1500 m level, where they remain isothermal for another 1000 m and then begin to decrease at a normal lapse rate of 5° C per 1000 meters (Wahl Unpubl.).

2.7 Vegetation

Within the Yukon Territory, regional aspects of the vegetation have been documented by Oswald and Senyk (1977). The major vegetational gradients result, in part, from climatic changes from west to east, south to north, and low to high altitudes, and in part from regional changes in edaphic factors (Orloci and Stanek 1979).

The Macmillan Pass / Sheldon Lake study area falls within the Mayo Lake-Ross River and Itsi Range Ecoregions (Oswald and Senyk 1977). Besides this very brief and general description of the vegetation in these two ecoregions, there is little information on the vegetation of the study area.

Porsild (1945, 1951) discussed the flora adjacent to the North Canol Road. Amax (1976) presented physiognomic vegetation types for the MacTung property, just north of Macmillan Pass. Moody (1980) described, very briefly, the vegetation communities of the Jason property, west of Macmillan Pass along the Canol Road. Brown (1983) described, in more detail, the vegetation of the Jason property. Kershaw (1983) described the vegetation of that portion of the North Canol Pipline right-of-way east of the continental divide.

The vegetation of the study area reflects the extreme environmental conditions in which it occurs. Many valley floors are not forested, hence there is a lower as well as an upper treeline. The upper treeline is between 1300 and 1550 m, depending on aspect, slope and latitude (Plate 1). The terrain below the upper treeline falls within the Eastern Yukon Boreal Forest Region, while that above the upper treeline lies in the Tundra Region (Rowe 1972).

The alpine tundra is characterized by ericaceous shrubs, lichens, mosses, and grasses. The non-treed subalpine areas are characterized by shrub birch and willow communities. An outstanding feature of both the subalpine and alpine zones is the occurrence of species-rich meadows, dominated by *Festuca altaica* and/or *Calamagrostis canadensis* and a wide variety of forbs.

Mid and upper slopes below the upper treeline are dominated by *Abies lasiocarpa* (subalpine fir). *Picea mariana* (black spruce) dominates on gentle lower slopes and some valley floors. *Picea glauea* (white spruce) is not as common as either black spruce or subalpine fir, occurring on alluvial plains and in seepage channels on slopes. *Pinus contorta* (lodgepole pine), common in the southern Yukon, is exceptionally rare. *Populus balsamifera* (balsam poplar) is not well represented, occurring on narrow floodplains and recent alluvium. *Populus tremuloides* (aspen poplar) and *Betula occidentalis* (river birch) occasionally occur on south-facing slopes following fires, which occur frequently in the study area.

The treeless vegetation of the valley floors consists predominantly of shrub birch-lichen on well-drained knobs and sedge wetlands in the poorly-drained kettles. Patterned fens are common in the wider valleys.

Plate 1. This print illustrates three distinct zones occurring in the Macmillan Pass / Sheldon Lake area: the alpine / non-treed subalpine zone; the forested zone; and the non-treed zone which occurs below the upper treeline.

3. Methods

3.1 Data Collection Methods

3.1.1 Pre-field Methodology

During the spring of 1981, prior to initiation of summer field work, reconnaissance level aerial photographic interpretation was carried out using 1976, 1:74,000, black and white panchromatic photography. A small gap in this coverage resulted in the use of 1978, 1:54,000, black and white panchromatic photography in the Fuller Lake area. Vegetation type delineation was based on differences in photograph tone, texture and color. Each type or unit delineated on the air photo was referred to as a polygon. Due to the small scale of photography and unfamiliarity of the area no attempt was made to identify polygons as vegetation communities previous to the field season.

A total of seven reconnaissance traverses were drawn on the air photos, attempting to include as many visually different types, on a variety of landscape types as was practical. Polygons were numbered along the traverse line to aid in recording data in the field. Traverse locations are included in Appendix VII.

3.1.2 Field Methodology

The traverses were flown throughout the summer using a Bell 206 Jet Ranger or a Hiller 12-E helicopter. Flying altitude was approximately 100 meters above the ground. Flying time for each traverse was approximately six hours. The Hiller 12-E was the more suitable helicopter due to increased visibility and slower speed.

As each polygon along the traverse was located and flown over, a tape recorder was used to record the dominant species, including shrubs, forbs, graminoids, and non-vascular species when they could be identified. The polygon was assigned an initial vegetation community based on growth form and major species. Several initial vegetation communities were often recognizable within one polygon.

Selection of communities to be sampled was based on information gathered in the reconnaissance traverses. An attempt was made to sample as many different vegetation community types as possible within the constraints of time and accessibility. Most sampling sites were accessed by helicopter, though as many as possible were placed within walking distance of the North Canol road. An attempt was made to minimize the number of helicopter hours required per sampling site by choosing sites along a foot traverse from mountain top to valley floor. Cross-sectional representation of four such traverses are presented in Figures 20 to 23.

Actual sites to be sampled were selected as being typical of the vegetation community following a walk-through of the area. An attempt was made to locate the sites close to the middle of the community to avoid edge-effect. A total of 454 sites were sampled. Site locations are shown in Appendix VII.

Site Description

At each site soils, vegetation, surficial geology, and site descriptions were completed. The site description was normally completed by two people. Time required per site was from an half an hour to a maximum of an hour and a half, depending on site complexity. Examples of forms used are in Appendix III.

Site description followed that outlined by Walmsley et. al. (1980). Variables described were location, elevation, macro and meso aspect, percent slope, slope nature, macro and meso site positions, microtopography, seepage, exposure type, flood hazard, and soil perviousness and drainage. Soil drainage classes are those defined by the System of Soil Classification for Canada (Can. Soil Survey Comm. 1978). Soil drainage classes are defined in terms of: 1) actual moisture content in excess of field moisture capacity, and 2) the length of the period during which such excess ground water is present in the rooting zone (Walmsley et.al. 1980). Soil perviousness refers to the potential of a soil to transmit water internally. It is a subjective classification, inferred from soil structure, texture, porosity, cracks, etc. Definitions of soil drainage and perviousness are in Appendix IV.

The ecological moisture regime (hygrotope) was assessed for each vegetation site. This is a relative ranking of site based on available moisture supplies over the entire growing season. It is strongly correlated with the following site factors: slope position, slope gradient, soil drainage, soil texture, soil depth, and the presence of an impermeable layer. The most influential factor is slope position (Walmsley et. al. 1980). Eight moisture classes were defined starting with very xeric and grading through mesic, hygric and hydric. All eight classes and their definitions are included in Appendix IV.

The vegetation description includes a list of plant species, separated into height classes and growth forms, and their respective percent cover, recorded in a visually estimated, 80 m^2, circular plot (diameter=10m). The ten growth form classes are as follows: tall trees (TT), >5 m; low trees (LT), <5 m; tall shurbs (TS), 1.5 - 5.0 m; medium shrubs (MS), 0.5 - 1.49 m; low shrubs (LS), 0.1 - 0.49 m; prostrate shrubs (GS), <0.1 m; forbs (FB), graminoids (GR), bryophytes (BR); and lichens (LN).

An attempt was made to develop a complete species list for each site. However, difficulty in identifying different species of *Salix* , Cladoneae lichens, Sphagna, and minor mosses precluded this. All *Salix* species were treated as one, as were all species of *Sphagnum*. Cladoneae lichens were grouped as *Cladonia* spp. unless they had red podetia, when they were classed as *Cladonia coccifera* . Minor mosses were often overlooked. However, specimens of *Salix, Cladonia* and the minor mosses were collected throughout the study area in an attempt to obtain a complete flora. All species recorded in the study area are listed in Appendix V.

A variable plot timber cruise was carried out in forest stands to obtain forest structure data. Unfortunately, time constraints and lack of equipment allowed timber cruises in only half of the forest sites. Methodology was that described by Walmsley et. al. (1980). Basal area (BA) was obtained using 2 and 5 BAF metric prisms. Diameter at breast height (DBH) was obtained using diameter tapes. Tree heights were obtained using Suunto clinometers. Stand age was determined by boring the largest tree in the stand using an increment borer. Growth rings were counted on the resulting core.

A soil profile description was made from a pit dug in the centre of the vegetation plot; soils were identified to the soil subgroup level, following the Canadian System of Soil Classification (Can. Soil Survey Comm. 1978). Average depth of the soil pit was 75 cm, less where the ground was frozen or where water or bedrock was present. Samples from each horizon were often collected for lab analysis. In many instances material was collected from only one or two horizons in order to assist in identifying soil type. However, an attempt was made to have several complete profile-descriptions for each major community type.

The <2mm soil fractions of the horizon samples were analyzed by the Analytical Services Labratory, Ag. Canada, Research Branch, Ottawa, for pH (0.01 M $CaCl_2$), %

organic carbon (dry combustion, induction furnace method), % total nitrogen, exchangable cations (me / 100 g, Ca, Mg, Al, permanent charge, neutral salt method), cation exchange capacity (me / 100 g, permanent charge, neutral salt, rapid method), % extractable iron and aluminium (sodium pyrophosphate method), electrical conductivity (MMHOS / cm, 1:5 soil:water paste) and particle size analysis (with pretreatment removal of carbonates, organic solids and salts, dispersion in sodium hexametaphosphate using the pipette method) (McKeauge 1979).

3.2 Data Analysis Methods

Mulitivariate analyses of community data provide a relatively efficient, objective method for shifting the level of abstraction from raw data, conveniently collected in terms of species abundance in samples, to community-level properties such as community types and community gradients (coenoclines) (sensu Whittaker 1975). Such analysis helps concentrate redundancy, reduce noise, elucidate relationships and indentify outliers within the data set (Gauch 1982).

The multivariate techniques used in the analysis of the Macmillan Pass vegetation data were classification and ordination (Gauch 1982).

The large data-set (454 sites) necessitated its division into three subsets for analysis: 1) alpine tundra sites and non-forested (<10% tree cover) subalpine sites; 2) forest sites (>10% tree cover) and 3) non-forested (<10% tree cover) sites occurring below the upper limit of treeline. Primary (recent alluvium) and secondary successional sites (burns) that would presumably succeed to forest stands were classed as such.

3.2.1 Classification of Plots

Plots were classified using the sequential, agglomerative, hierachical, non-overlapping technique (SAHN) of complete-linkage cluster analysis, available in the CLUSTAN 1C suite of computer programs (Wishart 1978) using actual % cover estimates of species as the data base for a similarity matrix. This cluster technique is noted for producing tight clusters of similar plots (Gauch 1982).

Hierachical classification groups similar plots together into classes and then groups the similar classes into larger classes, producing a dendogram. Two advantages of a hierarchy are 1) that a single analysis may be viewed on several levels, variously general or detailed, and 2) that relationships are expressed among the entities classified. Agglomerative classification begins by treating each plot as a single cluster and combines these in a hierarchy of larger and larger clusters until a single cluster contains all plots (Gauch 1982).

Community coefficients or indices of similarity (IS) were calculated by CLUSTAN for each cluster. The IS for a cluster is the smallest single similarity coefficient between two individuals within that cluster. Similarity of any two clusters was calculated by the following algorithm:

$$IS = \frac{U_{jp} U_{jq}}{U^2_{jp} - U_{jp} U_{jq} + U^2_{jq}}$$

where: U_{jp} - denotes the mean of variable j for cases comprising cluster p.

This is a mathematical expression of community similarity, where 0.0 indicates that there is no species in common between plots and 1.0 indicates qualitatively and quantitatively identical plots. It is important to note that replicate community samples (different samples from the same small homogeneous community) are rarely identical. They have average similarities of 0.5 to 0.9, depending on sample size, the precision of measurements or estimates, the number of species, etc. (Gauch 1982).

Resulting clusters were examined to determine if they were ecologically meaningful groupings. A cluster was considered ecologically meaningful, and thus a community type, when it consisted of similar plots occurring on similar site types. If a cluster contained stands that had similar species composition, but occurred on differing site types, it was broken down into the appropriate number of community types, or, in some cases, subtypes. This most often occurred when the sites were dominated by an ubiquitous species that occurred over a wide range of site conditions.

Groups of four or more sites were recognized as a community type (CT), whereas smaller groups were regarded as tentative or possible community types (TCT) since the data were not adequate to accurately describe or delimit them.

Clusters that had plots occurring on similar site types and had similar species composition, but appeared to be visually different due to the relative cover of one or more species were classed as a community type with several 'phases'. Phases often represent successional stages of a community.

Prevalent species were used to name and characterize the communities. Names most often contain the dominant species from the two most dominant growth forms. Where this would result in identical names for two communities, a third species was added. The physiognomically taller growth-form was always listed first regardless of relative percent cover. In mature forest stands a tree species was always used; usually in conjunction with an understory species.

3.2.2 Ordination of Plots and Species

The purpose of ordination is to summarize community data by arranging species and plots in a few-dimensional space such that similar entities are close together and dissimilar ones are far apart. This results in species and plots arranged along one to several axes which may represent significant environmental gradients (Gauch 1982).

Species and plots were ordinated using Detrended Correspondence Analysis (DECORANA), an improved eigenvector technique based on reciprocal averaging (Hill 1979a). Both plots and species are positioned along the same four axes. An eigenvalue and axis length are given for each axis. The eigenvalue indicates how much of the total variation in the data is accounted for by each axis. The unit of length, or ordination length, is termed the 'average standard deviation' of species turnover or SD. As a generalization, a full turnover in species composition of sites will occur in 4 SD. This distance will vary depending on data-set noise. [3] The longer the axis the longer the community gradient (Gauch 1982).

The three relatively disjunct data-subsets were analyzed seperately. The below-treeline, non-treed data-subset was again split into two data sets, well-drained shrub communities and fen/bog communities.

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[3] Noise is defined here as variation in species abundances not coordinated with variation in other species' abundances. Noise implies uncoordinated and apparently chance differences in species abundances. The biological causes of noise include chance distribution and establishment of individuals, animal activity, disturbance, and environmental heterogeneity at a scale not recognized in the sampling technique. Noise also results from limitations in measuring or estimating species abundance and from statistical limitations of finite samples (Gauch 1982).

3.2.3 Correlations with Environmental Factors

The environmental gradients associated with the ordination axes were determined by correlating plot positions on the axis with environmental variables. Correlations were determined using the Michigan Interactive Data Analysis (MIDAS) command CORR (Fox and Guire 1976). Semi-quantitative variables such as drainage and ecological moisture were ranked.

Correlation with elevation was determined with elevation as recorded and aspect-adjusted elevations. Since steep southwest-facing slopes are generally warmest and steep northeast-facing slopes are coolest in the northern hemisphere (Geiger 1965), and slope angle accentuates this difference, plot elevations on greater than 10% slopes were adjusted downward 100 meters on southwest aspects, upwards 100 meters on northeast aspects, and not at all on on southeast and northwest aspects. They were adjusted interpolated distances for intermediate slopes and aspects, and not at all for 0 - 10% slopes of all aspects (La Roi and Hnatiuk 1980).

Aspect was transformed using the procedure proposed by Trimble and Weitzman (1956) and modified by Beers, Dress and Wensel (1971). Using a sine transformation, southwest aspects, which are the warmest, receive a value of 2, and northeast aspects a value of zero. The scale then grades equivalently in both directions so that both SE and NW receive a value of 1.0.

Since slope and aspect interact in such a way that steep north-facing slopes receive the least solar radiation, and south-facing slopes receive the most (Buffo et. al. 1972), a variable, 'slope X aspect', was computed. Southwest aspects were given a value of 1, and northeast aspects a value of -1. SE and NW were given a value of 0.001 (to avoid multiplying by zero). The value for aspect was then multiplied by the percent slope. Therefore, steep southwest-facing slopes have the largest value, and steep northeast-facing slopes the smallest (a negative) value. This transformation is not ideal, because in reality, depending on the time of the year, and therefore solar angle, 100% SE slopes will recieve less solar radiation than 30% SE slopes.

Soil variables, such as nutrients and pH were described by horizon, not by a consistent depth in the profile. Horizons used in the correlation calculations were those with either plentiful or abundant roots. Where root abundance was not recorded, unfrozen horizons above the depth of 15 cm were used, as this is the zone in which roots were usually most plentiful.

Soil pH was recorded both in the field (Hellige-Trulog method) and in the lab. As samples from all profiles were not collected for lab analysis, a correction factor between field pH and lab pH was calculated through a simple linear regression. Soil pH's used in the data analysis were lab pH and corrected field pH.

After the environmental gradients represented by the ordination axes were determined, the clusters and communities were plotted on the XY ordination fields. The positions of the major species on the ordination space were examined to determine their usual range of site conditions. These were checked using Chi-square tests of indepedence, Student's t-test and Mann-Whitney tests. Chi-square tests were used with qualitative attributes, such as slope position, to determine if a particular species occurred more times than expected by chance on, for example, upper slopes. Student's t-tests were used to determine if there was a significant difference within a quantitative variable for sites with and without the species in question. Where variances were not equal the non-parametric Mann-Whitney and Median tests were used (Steele and Torrie 1980).

For certain species a comparison of means was used to determine if the mean for a variable was significantly different between plots with different species, e.g., was the %N of the rooting zone significantly different in plots with *Pleurozium schreberi* than in plots with *Hylocomium splendens* .

Duncan's Multiple Range test was used to determine if there were significant differences between the means of soil nutrients for different community types (Steele and Torrie 1980). Data were analyzed by horizon.

MIDAS was used for all univariate statistical tests, except Duncan's when SPSSx was used. For all statistical tests, differences were considered significant when alpha < 0.05.

4. Alpine Communities

4.1 Overview of Alpine Communities

The alpine zone and non-treed parts of the subalpine zone of the Macmillan Pass study area are found between 1150 and 1890 m. This zone is defined as that area above the upper limit of treeline. It does not include sites with krummholz growth forms, which are classed with the forest sites. The majority of sites are situated on level to steeply sloping morainal or colluvial veneers and blankets, with predominantly imperfectly to rapidly drained Brunisolic and Regosolic soils. Of 83 soil profiles, 3 had water present at depths of 10 to 100 cm., and 8 had frost present at depths of 10 to 25 cm.

The flora of this zone is relatively diverse. One hundred and forty-nine (149) vascular species in 76 genera and 46 non-vascular species in 21 genera were recorded in 106 stands. In terms of major growth forms there are 16 erect shrubs (including 3 tree species), 13 prostrate shrubs, 85 forbs, 24 graminoids, 8 pteridophytes, 28 bryophytes and 18 lichens.

Bryophytes and fruticose lichens are the dominant growth forms in terms of plant cover. *Polytrichum juniperinum* and *Stereocaulon* sp. are rather ubiquitous, occurring in 76 and 69 stands respectively. The most common lichen is *Cladina stellaris*, followed by *Cladina rangiferina* , *Cetraria nivalis* , and *Cetraria cucullata* . *Alectoria ochroleuca* also occurs frequently. *Nephroma arcticum* is the common foliose lichen, though *Peltigera aphthosa* also occurs.

The most common mosses after *Polytrichum juniperinum* are *Dicranum* sp. and *Aulacomnium palustre* . Feathermosses are also common, with *Pleurozium schreberi* occurring more often than *Hylocomium splendens* . Sphagna are rare.

There is a great diversity of forbs. Two of the more ubiquitous are *Artemisia arcticum* and *Gentiana glauca* . *Anemone* spp. and *Senecio* spp. are common. Forb meadows, characterized by *Mertensia paniculata* , *Senecio triangularis* , *Veratrum viride* , *Aconitum delphinifolium* and *Delphinium glaucum* , are an interesting feature of this zone. Several of these species are biogeographically significant in terms of their occurrence in the study area: *Senecio triangularis* and *Veratrum viride* are at or near their northern limits of distribution, while *Aconitum delphinifolium* is at or near its eastern limits (Polumin 1959). *Mertensia paniculata* , described by Porsild (1951) as a lowland species common in rich woods, along river banks and on peaty soils, also grows at alpine elevations in the study area.

Graminoids cover a significant portion of the ground in many stands. *Festuca altaica* is the most widespread followed by *Carex podocarpa* , *Hierochloe alpina* , and *Luzula parviflora* .

Vaccinium vitis-idaea is the most common prostrate shrub, followed by *Cassiope tetragona* and *Empetrum nigrum* . *Dryas integrifolia* occurs in only eight stands. *Salix* spp. are the dominant erect shrubs, occurring in almost half of the stands. Porsild (1951) noted that *Salix barrattiana* is the common species that forms thickets on well-watered alpine flats, especially in areas where there is a great accumulation of snow. *Salix pulchra* is the common willow on grassy slopes and gravelly river terraces. Amax (1976) found that on subhygric to mesic , lower alpine and subalpine slopes *Salix commutata* is the common willow, with *S. glauca* and *S. barclayi* being second and third in abundance. *Salix pulchra* and *S. glauca* were found to be the most common willows on submesic sites with coarse-textured soils. *Vaccinium uliginosum* and *Betula glandulosa* are common shrubs.

Lycopodium alpinum and *Lycopodium selago* are common pteridophytes.

4.2 Cluster Analysis of Stands

Results of the SAHN complete linkage cluster analysis are shown in the dendrogram in Fig. 2. Size constraints of the clustering program necessitated that those species which occurred only in trace amounts (<1% cover) in fewer than 10% of the stands were excluded from the input data. The locations of the clusters on the DECORANA ordination are shown in Fig. 3.

The resulting 16 clusters are rather loose groupings of plots with similar species composition. The clusters can be sorted into four major groups: lichen-dominated (9,14,15), bryophyte-dominated (2,5,6,10,11), graminoid dominated (1,4,7,8), and shrub dominated (3,11,12,13). Environmental factors often vary considerably within a cluster and, therefore, each cluster may contain several distinct community types. Groups of four or more sites are recognized as community types (CT's), whereas smaller groups are regarded as tentative or possible community types (TCT's) since the data are not adequate to accurately describe or delimit them. Nine community types and 21 tentative community types are recognized. Site data and species cover data for each of four sites in the major community types are included in Tables 2 - 5.

Cluster 1 (IS=.343) consists of 3 plots dominated by *Calamagrostis canadensis* . *Hylocomium splendens* is the dominant moss. Environmental conditions are quite different among the stands, and two TCT's are recognized. It is possible that site 3 should have been included in the non-forested, below-treeline zone. This cluster is most similar to Cluster 2.

Cluster 2 (IS=.118) consists of 11 subalpine stands characterized by an almost continuous bryoid mat, dominated by *Hylocomium splendens* . *Calamagrostis canadensis* , which characterized Cluster 1 (CL #1), is rare. This cluster can by divided into 1 CT, characterized by MS *Salix* sp. or *Betula glandulosa* , and two TCT's, one charaterized by *Cassiope tetragona* , and one by the absence of shrubs and the dominance of forbs.

Cluster 3, which consists of a single site (72), is most similar to Cluster 2. Cluster 3 is dominated by *Salix* sp.

Cluster 4 (IS=.120) consists of 9 sites and is characterized by *Festuca altaica* . This cluster contains one subalpine CT, and two TCT's, one of which can be classified as subalpine, and one as alpine. In addition to *Festuca altaica* , the subalpine types are characterized by forbs or *Salix* sp. and the alpine type by *Cassiope tetragona* . Cluster 4 is most similar to Cluster 5.

Cluster 5 (IS=.208) consists of 7 stands characterized by *Pleurozium schreberi* . *Festuca altaica* is common. These plots occur over a wide range of environmental conditions, and four TCT's are recognized within it.

Cluster 6 is a loose cluster (IS=.130) similar to Clusters 4 and 5. It consists of 3 sites, each a TCT, characterized by the dominance of *Aulacomnium* sp. . The plots have no other major species in common.

Cluster 7 (IS=.590) consists of two poorly drained sites dominated by *Carex aquatilis* . These sites should possibly have been included with the non-forested, below treeline sites.

Cluster 8, which is most similar to Cluster 7, consists of a single site dominated by *Carex aquatilis* and *Tomenthypnum nitens* .

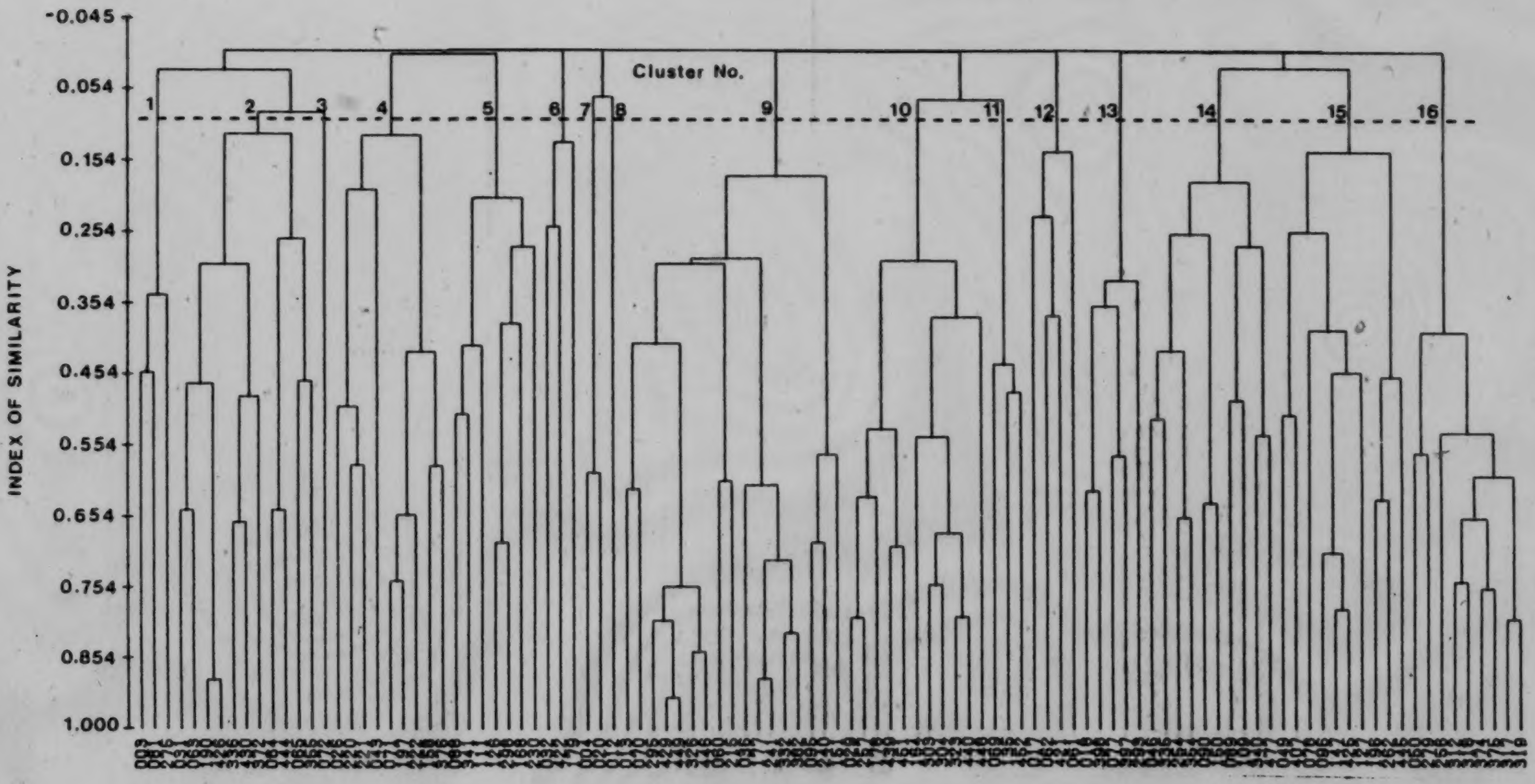


Figure 2. Complete-linkage cluster analysis dendrogram of the 106 sites in the alpine and non-treed subalpine zone. Site numbers are along the bottom. The dashed line indicates the cluster cutoff point.

Cluster 9 (IS=.177) consists of 17 stands characterized by a high cover of *Cladina stellaris* . *Cassiope tetragona* is the most common shrub, but does not occur in the low elevation stands. This cluster contains one distinct CT and 3 TCT's. It is most similar to Cluster 10.

Cluster 10 (IS=.295) consists of 11 sites characterized by high cover values of *Dicranum* sp. and *Polytrichum juniperinum* . *Cassiope tetragona* is usually present and *Cladina stellaris* is often present. It is considered a CT.

Cluster 11 (IS=.44) consists of 3 north-facing stands dominated by *Cassiope tetragona* . *Polytrichum juniperinum* also occurs with a relatively high cover. Cluster 11 is most similar to Cluster 10.

Cluster 12 (IS=.143) is most similar to Clusters 10 and 11. It consists of 4 stands characterized by a high cover of *Dryas integrifolia* and *Salix reticulata* . The species characterizing Clusters 10 and 11 are rare.

Cluster 13 (IS=.232) consists of 5 well-drained sites dominated by *Betula glandulosa* . Other species with 100% constancy are *Empetrum nigrum* and *Salix* sp. . This cluster is most similar to Clusters 14 and 15.

Cluster 14 (IS=.258) consists of 10 plots characterized by a high cover of *Alectoria ochroleuca* .

Cluster 15 (IS=.143) consists of 10 stands characterized by a high cover of *Stereocaulon* sp. . *Alectoria ochroleuca* is often present. Prostrate ericaceous shrubs are common.

Cluster 16 (IS=.423) consists of 9 sites dominated by *Polytrichum juniperinum* . This cluster consists of one community and two TCT's (sites 50 and 279).

4.3 Community Type Descriptions

4.3.1 Salix sp.-Betula glandulosa/Hylocomium splendens CT

CL# 2, IS=.117, n=7:31,63,64,65,355,372,444

SASP-BEGL/HYSP is a subhygric, subalpine community occurring on level valley floors and moderately sloping, lower to mid-slope sites between 1370 and 1650 m. Soils are typically slowly to rapidly pervious, imperfectly drained Gleysols and Cryosols formed on morainal blankets and veneers. Water was present in 4 of 7 soil profiles at depths of 5 to 20 cm. Frost was present in 2 profiles at depths of 10 and 13 cm.

This community is characterized by a high cover of erect shrubs (12-34%, x=23%), dominated by MS *Salix* sp. and/or *Betula glandulosa* . *Salix* sp. is always present, though occasionally in trace amounts, when *Betula glandulosa* is then dominant. *Empetrum nigrum* , *Vaccinium vitis-idaea* , and *V. uliginosum* are the common ericaceous shrubs. *Ledum palustre* may occasionally occur, but always with a low cover value. *Festuca altaica* and *Carex podocarpa* are common graminoids. There is an essentially continuous bryoid mat dominated by *Hylocomium splendens* . *Sphagnum* sp. , *Tomenthypnum nitens* , and *Polytrichum juniperinum* may also be present. *Cladina mitis* and *C. stellaris* often occur.

Plate 2. SASP-BEGL/HYSP CT. Site 63, north flank of Keele Peak. (63° 32′ 70″ N, 130° 15′ 00″ W). Elevation - 1550 m. This site was dominated by TS and MS *Salix* sp., and LS *Betula glandulosa* . *Hylocomium splendens* was the dominant bryophyte (40% cover). *Festuca altaica* was the common grass (20% cover). Twelve species of forbs were present, lichens occurred in trace amounts. Date sampled - June 24, 1981.

Plate 3. Regosolic Static Cryosol, Site 63, SASP-BEGL / HYSP CT.
Water was present at 10 cm, frost present at 13 cm. A thin ash layer is present just below the LFH. Date sampled was June 24.

4.3.2 Festuca altaica/Forb CT

CL# 4, IS=.207, n=5:43,71,158,197,376

FEAL/FORB is typically a mesic subalpine community type occurring on moderately to steeply sloping sites, between 1370 and 1590 m. Soils are moderately pervious, moderately well to well-drained Podzols and Regosols formed on colluvial material. The pH of the rooting zone ranges from extremely acidic (3.9) to very strongly acidic (4.9).

Within this community graminoids are usually dominant (18-77%, x=50%). *Festuca altaica* is the dominant species with between 15 and 65% cover. *Carex podocarpa* is usually present with a low cover value. Forbs are numerous, with *Epilobium angustifolium* , *Artemisia arcticum* , and *Mertensia paniculata* being most common. Lichens are rare or absent. *Polytrichum juniperinum* and *Pleurozium schreberi* may occur. Ericaceous shrubs do not commonly occur but may be present.

Plate 4. FEAL/FORB CT, Site 71, SW of Emerald Lake, 63° 27' 90" N, 131° 23' 00" W. Elevation - 1590 m. This site is dominated by *Festuca altaica* (65% cover), and *Epilobium angustifolium* (30% cover) and *Mertensia paniculata* (20% cover). Thirteen forb species were recorded. See Plate 5 for soils. Date sampled - June 27, 1981.

Plate 5. Orthic Humo-Ferric Podzol, formed on a colluvial blanket, FEAL/FORB CT, Site 71. Depth to the BC horizon was 74 cm. No ash layer was present.

4.3.3 Festuca altaica/Polytrichum juniperinum CT

CL# 16, IS=.538, n=7:256,312,317,318,319,374,375

FEAL/POJU is a mesic subalpine and alpine community type occurring on south and west-facing, gentle to steeply sloping sites between 1475 and 1708 m. Soils are typically moderately to rapidly pervious, moderately well to well-drained Eluviated Dystric and Orthic Dystric Brunisols, occurring on morainal parent material. Occasionally this type occurs on colluvial material. The pH of the rooting zone ranges from extremely to very strongly acidic (3.5-4.9).

The community is characterized by a very high cover of bryophytes (60-80%, x=70%), with *Polytrichum juniperinum* (45-65%) predominating. *Pleurozium schreberi* and *Dicranum* sp. often occur, sometimes with a moderately high cover value. *Festuca altaica* is the second diagnostic species, with a cover range of 3-40%, but which most often ranges from 10 to 20%. *Carex podocarpa* has 100% constancy, but a very low cover value. *Stereocaulon* sp. always occurs, often with a high cover value. Other fruticose lichens occur, but always with a very low cover value. Total lichen cover varies considerably, from 5 to 35%. Forbs are not common, but those that occur most often are *Artemisia arcticum* and *Anemone* spp. Shrubs usually occur, occasionally with a cover value reaching 30%. Ericaceous shrubs are most common though *Betula glandulosa* and erect Salices may occur.

4.3.4 Betula glandulosa/Stereocaulon sp. CT

CL# 13, IS=.323, n=5:18,77,293,397,398

BEGL/STSP is typically a submesic to subxeric, subalpine community occurring on gentle to steep sites between 1500 and 1780 m. Soils are typically moderately pervious, well-drained Brunisols and Regosols, formed on colluvium, morainal material, or decomposed bedrock. The pH of the rooting zone is very strongly acidic (4.7-4.9).

This community is dominated by LS or MS *Betula glandulosa* (30-70%), which is present as a continuous canopy or in small clumps interspersed with lichens and graminoids. The only other species present with 100% constancy are *Stereocaulon* sp. (2-30%) and *Empetrum nigrum* (<1-3%). Understory is variable; with lichens or grasses dominant in the openings, and bryophytes dominant directly under the shrubs. Common lichens in addition to *Stereocaulon* sp. are *Cladina stellaris* . *C. rangiferina*, and *Cetraria nivalis* . Total lichen cover varies from 5 to 50% (x=43%). Low values occur on sites where there are few or no openings in the shrub canopy. Common mosses are *Pleurozium schreberi* , which is common under the denser shrubs, and *Polytrichum juniperinum* . Graminoids are represented by *Hierochloe alpina* and *Arctagrostis latifolia* , which are especially common on high elevation sites.

4.3.5 Cassiope tetragona/Dicranum sp.-Polytrichum juniperinum CT

CL# 10, IS=.295, n=11:29,164,178,257,303,304,323,439,440,448,451

CATE/DISP-POJU is a mesic to submesic alpine community type occurring on level to steeply sloping sites between 1470 and 1860 m, which is approaching the upper limits of vascular vegetation. Soils are typically moderately pervious, moderately well to well-drained Dystric Brunisols. Cryosols and Regosols may also be found. Water was present in one of the soil profiles at a depth of 45 cm. pH of the rooting zone is extremely to very strongly acidic (3.9-4.9).

This is a bryophyte-dominated community (25-90%, x=60), characterized by a high cover of *Dicranum* sp. . *Polytrichum juniperinum* (5-40%) is occasionally codominant with *Dicranum* sp. but never surpasses it.

Prostrate shrubs are commonly represented by *Cassiope tetragona* which usually attains a cover of 20%, though it can be as high as 35%. *Vaccinium vitis-idaea* , occurring with a low cover, is the second most common ericaceous shrub. Others are rarely present. The pteridophyte *Lycopodium alpinum* often occurs, but usually with a low cover value. Graminoids are represented by *Festuca altaica* and *Luzula parviflora* , both occurring with a high constancy, but a low cover value. Forbs are numerous on low-elevation sites with *Artemisia arcticum* and *Gentiana glauca* being most common; but very scarce near the upper limit of vegetation where species diversity of most growth forms is low. The dominant lichens are *Cladina stellaris* , *C. mitis* and *Stereocaulon* sp. . Total lichen cover varies from 5 to 55% (x=24%); and is lowest on high elevation sites.

Plate 6. CATE/DISP/POJU CT, Site 29, Elevation - 1690 m. Situated on a NW facing slope, with a well-drained Orthic Dystric Brunisol formed on a colluvial veneer. *Cassiope tetragona* has a cover of 35%, *Lycopodium alpinum* a cover of 10%. *Festuca altaica* and *Luzula parviflora* are the graminoids present. *Dicranum* sp. has a cover of 35%. Date sampled - June 19, 1981.

4.3.6 Cassiope tetragona/Cladina stellaris CT

CL# 9, IS=.298, n=11:36,70,177,241,326,332,429,446,449

CATE/CLST is typically a submesic, upper slope alpine community. It occurs on level to steeply sloping sites between 1430 and 1770 m. Soils are usually well-drained Dystric Brunisols and Orthic Regosols found on colluvium though morainal material and bedrock also occur. pH of the rooting zone is extremely to strongly acidic (4.3-5.2).

This is a lichen-dominated community characterized by a high cover of *Cladina stellaris* (30-60%). Other lichens which occur frequently, often with a high cover value are *Stereocaulon* sp. , *Cetraria islandica* , *C. nivalis* and *C. richardsonii*. Other Cladoniae and Cladinae lichens occur infrequently. Total lichen cover varies from 50 to 75% (x=65%).

The dominant vascular species is *Cassiope tetragona* which has a cover value of 12-30%. Other ericaceous shrubs, with *Vaccinium vitis-idaea* being most common, are almost always present. Total shrub cover varies between 20 and 40% (x=30%). *Festuca altaica* , *Hierochloe alpina* , and *Luzula parviflora* are common graminoids, whose total coverage rarely surpasses 10%. *Polytrichum juniperinum* is the most common bryophyte, occasionally achieving 50% cover.

Plate 7. CATE/CLST CT, Site 326, Itsi Lakes, (62° 45' 50" N, 130° 19' 90" W). Elev. - 1750 m. The soil is a rapidly drained Orthic Regosol formed on bedrock. Date sampled - July 28, 1981.

4.3.7 Ericaceous Shrub / Stereocaulon sp. CT

CL# 15, IS=.143, n=10:49,78,96,127,147,196,262,407,425,445

ERICAD / STSP is typically a mesic to submesic alpine community found on level to steeply sloping, southerly-facing slopes. Soils are moderately to rapidly pervious, moderately well to rapidly drained Brunisols and Podzols. This community occurs predominantly on rock parent material, less often on colluvium or morainal material. The pH of the rooting zone is extremely to very strongly acidic (4.3-4.9).

This is a lichen-dominated community (25-95%, x=65), with both *Stereocaulon* sp. (15-50%), and *Cladina stellaris* (<1-45%) having 100% constancy. *Cetraria nivalis* , *C. cucullata* and *C. richardsonii* may also achieve a relatively high cover. Total bryophyte cover varies from 2 to 40% (x=16%). Those often present with high cover are *Dicranum* sp. and *Aulacomnium* sp. . One of *Empetrum nigrum* , *Vaccinium uliginosum* , or *V. vitis-idaea* is present, sometimes with a cover reaching 25%. Graminoids are represented by the two major alpine species, *Hierochloe alpina* and *Festuca altaica* . Common forbs are *Artemisia arcticum* and *Gentiana glauca* .

Plate 8. ERICAD / STSP CT, Site 96, NW of Niddery Lake, (3° 21′ 40″ N, 131° 31′ 40″ W). Elev. - 1490 m. Soil - O.HFP formed on bedrock. Date sampled - July 1, 1981. Dominant shrub is *Vaccinium uliginosum* (20% cover). *Stereocaulon paschale* is the dominant lichen (30% cover), *Cetraria nivalis* has a cover of 15%.

4.3.8 Ericaceous Shrub / Alectoria ochroleuca CT

CL# 14. IS=.258. n=10 46,89,90,109,150,254,335,340,354,447

This is a predominantly submesic to subxeric alpine community type, occurring on gentle to moderately sloping, upper slopes and apices, between 1350 and 1730 m. Aspect is usually south or west-facing. Soils are typically moderately to rapidly pervious, well to rapidly drained Eluviated Dystric Brunisols. The pH of the rooting zone is extremely acidic (3.8-4.4). Parent material is usually morainal material or bedrock, though both colluvium and alluvium also occur.

This is another lichen-dominated community , with total lichen cover varying from 26 to 95% (x=37). *Alectoria ochroleuca* is usually the dominant lichen, though it may occasionally be codominant with *Cladina stellaris* or *Stereocaulon* sp. . *Stereocaulon* sp. and *Cetraria cucullata* are always present, often with a relatively high cover (<1-20%). *Cetraria nivalis* is almost always present, with a cover value that may reach as high as 40%. Bryophytes are common, though their total cover (<1-65%, x=22) rarely exceeds that of lichens. On north-facing slopes *Dicranum* sp. is sometimes dominant. *Pleurozium schreberi* is a common bryophyte, but does not have as high a constancy as *Dicranum* sp. or *Polytrichum juniperinum* . Graminoids are represented by *Hierochloe alpina* , which has 100% constancy and a cover value of <1-20%. LS and GS are common. *Vaccinium vitis-idaea* has 100% constancy, with a cover ranging from <1-25%, and is often the dominant shrub. Occassionally *Arctostaphylos rubra* , or more rarely *Betula glandulosa* or *Salix* sp. are the dominant shrubs. Forbs present in trace amounts are *Anemone narcissiflora* , *Gentiana glauca* , and *Pedicularis labradorica* .

Plate 9. ERICAD / ALOC CT. Plot 150. South of Niddery Lake, (63° 21' 00" N, 131° 21' 70" W). Elevation - 1600 m. Soil is a well-drained Orthic Dystric Brunisol formed on bedrock. The site is dominated by *Alectoria ochroleuca* (50%) and *Cetraria nivalis* (40%). Date sampled - July 11, 1981.

4.3.9 Dryas integrifolia-Salix reticulata CT

CL# 12, IS=.143, n=4:17,61,62,421

DRIN-SARE is a submesic, high-alpine community type occurring on level apices, and gentle to steeply sloping upper slope sites, between 1640 and 1880 m. This is approaching the upper limit of vascular plant growth, and DRIN/SARE is one of the highest community types.

Exposed bedrock and colluvium are common on higher elevation sites. Soils are typically moderately pervious, moderately well to well-drained Cryosols and Regosols, though at lower elevations Orthic Eutric Brunisols may be found. On slopes the parent material is colluvium, while on the apices it is decomposed bedrock. Frost was present in one soil profile at a depth of 25 cm. This community type occurs on the most neutral soils in the subalpine and alpine zone, with the pH of the rooting zone being only slightly acidic (6.1) in 3 of the sites. These sites occurred in the northeast corner of the study area. The site which had a low pH (4.9) was located in the very southwest corner of the study area.

This community is characterized by the presence of *Salix reticulata* (5-30%) and *Dryas integrifolia* (5-15%). *Dryas integrifolia* , a calciphile, rarely occurs in other community types. Ericaceous shrubs are rare, with *Vaccinium* spp. occurring sporadically, and *Empetrum nigrum* never occurring. Forbs occur frequently, but not one species is common to all stands. Some of the forbs which do occur are *Anemone drummondii* , *Anemone multifida* , *Artemisia arcticum* , *Lupinus arcticus* , and *Potentilla uniflora* . Total forb cover is ca. 10%. The most frequently occurring lichens are *Alectoria ochroleuca* and *Cetraria nivalis* . Cladoniae and Cladinae lichens are very rare or absent. Bryophytes are represented by *Dicranum* sp. , *Pleurozium schreberi* , and *Tomenthypnum nitens* . Total lichen and bryophyte cover varies greatly, from trace amounts to 30%.

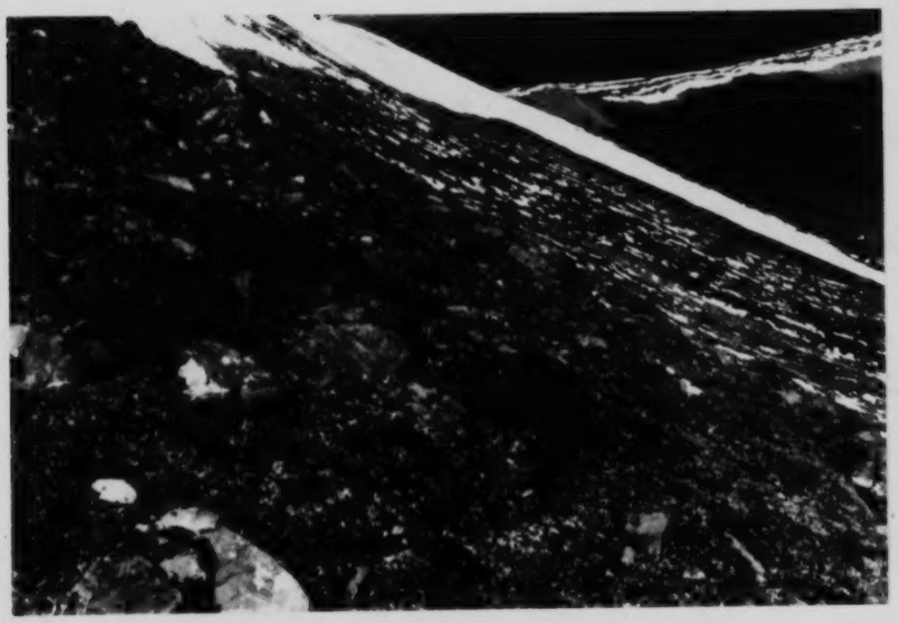


Plate 10. DRIN-SARE CT, Site 62, North flank of Keele Peak, (63° 52' 50" N, 130° 16' 60" W). Elevation - 1830 m. This site is characterized by *Dryas integrifolia* (15%) and *Salix reticulata* (10%). *Tomenthypnum nitens* is the dominant moss. Soil is a R.SC, formed on a colluvial veneer. Date sampled - June 24, 1981.

Table 2. Site data for four sites in four lichen-dominated CT's occurring in the non-forested subalpine and alpine zones in the Macmillan Pass study area. Plant species cover data are in Table 3. A '*' indicates that a photograph of the site is included in the text.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth to Water	Depth to Frost	Soil Subgroup	Terrain Type
CATE/CLST CT											
36.	1635.	S	31.	US	M		W	-.	-.	EDYB	$ -M.V
70.	1750.	NW	58.	US	R	SX	W	-.	-.	ODYB	GK-C.S
326.*	1750.	N	3.	A	M	M	R	-.	-.	OR	-A.P
429.	1550.	N	4.	US	M	SM	W	-.	-.	OR	RG-C.B
ERICAD/ALOC CT											
46.	1615.	S	0.	A	R	M	W	-.	-.	EEB	R -C.V
90.	1450.	S	0.	MS	M	SM	I	-.	-.	EDYB	R$-R.M
150.*	1600.	SW	10.	US	M	SX	W	-.	-.	ODYB	R -M.B
335.	1350.	N	10.	A	R	M	W	-.	-.	EDYB	GK-M.V
ERICAD/STSP CT											
49.	1645.	S	25.	US	R	SM	W	-.	-.	OHFP	RS-C.V
96.*	1490.	SW	21.	US	M	SM	MW	-.	-.	OHFP	-R.M
262.	1525.	SW	42.	US	M	M	MW	-.	-.	EDYB	R -C.B
425.	1540.	NW	5.	A	M	M	W	-.	-.	EEB	-M.V
BEGL/STSP CT											
18.	1500.	SE	1.	MS	M	SX	W	-.	-.	OR	R$-C.B
77.	1775.	S	22.	US	M	SM	MI	-.	-.		
398.	1518.	W	15.	MS	M	SX	W	-.	-.	OR	FB-M.V
293.	1615.	S	50.	US	M	SM	W	-.	-.		-R.S

Table 3. Estimated % cover of plant species in four sites in each of four lichen-dominated communities in the Macmillan Pass/Sheldon Lake region. A '+' indicates occurrence in trace amounts, a '--' indicates species absence. Site data are presented in Table 2.

	Lichen dominated community types and site numbers															
	Cate/Clst				Ericad/Aloc				Ericad/Stsp				Begl/Stsp			
Species	36	70	326	429	46	90	150	355	49	96	262	425	18	77	293	398
Trees																
Abies lasiocarpa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	6
Erect Shrubs																
Vaccinium uliginosum	5	-	-	-	-	5	1	-	3	23	10	8	-	-	25	1
Betula glandulosa	--	--	--	--	--	16	--	2	--	10	--	--	70	30	35	45
Ledum palustre	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--
Salix sp.	--	--	--	--	6	--	--	+	--	--	--	--	--	--	5	1
Spiraea beauverdiana	--	--	--	--	--	--	--	--	--	--	--	--	2	+	--	--
Prostrate Shrubs																
Cassiope tetragona	20	30	15	18	--	--	--	--	20	--	--	5	--	--	--	8
Phyllodoce empetriformis	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vaccinium vitis-idaea	+	--	1	2	+	5	10	15	1	8	10	15	10	10	7	--
Arctostaphylos rubra	--	--	--	--	--	20	--	--	--	--	15	--	--	--	--	--
Empetrum nigrum	--	--	--	--	--	15	--	5	1	5	15	10	+	1	+	3
Arctogrostis alpinum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	35	--
Salix reticulata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+
Juniperus communis	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--
Forbs																
Artemisia arcticum	--	3	+	3	--	--	--	--	3	1	+	1	--	--	--	--
Gentiana glauca	+	--	+	+	+	--	--	+	+	--	+	1	--	--	--	--
Oxyria dignya	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Petasites frigidus	--	2	--	--	--	--	+	--	--	--	--	--	--	--	--	+
Polemonium acutiflorum	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	+
Pyrola asarifolia	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Saxifraga tricuspidata	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Senecio atropurpureus	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--
Rubus arcticus	--	--	--	--	--	--	--	+	--	--	--	--	--	--	--	--
Rumex arcticus	--	--	--	--	--	--	--	+	--	--	--	2	--	--	--	--
Anemone multifida	--	--	--	--	--	--	--	--	2	1	--	--	--	+	+	--
Anemone narcissiflora	--	--	--	--	--	--	--	--	--	--	+	+	--	--	--	--

Table 3 continued.

Species	Lichen dominated community types and site numbers															
	Cate/Clst				Ericad/Aloc				Ericad/Stsp				Begl/Stsp			
	36	70	326	429	46	90	150	355	49	96	262	425	18	77	293	398
Pedicularis labradorica	--	--	--	--	--	--	--	--	--	--	+	--	--	1	+	--
Polygonum alaskanum	--	--	--	--	--	--	--	--	--	5	--	--	--	1	--	--
Dodecatheon frigidus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4
Epilobium angustifolium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--
Pedicularis labradorica	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+
Polygonum viviparum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+
Graminoids																
Carex podocarpa	--	--	--	+	--	--	--	--	--	2	--	+	--	--	--	--
Festuca altaica	30	--	--	+	--	--	--	+	5	8	--	2	--	--	--	--
Festuca brachyphylla	--	2	--	--	--	--	--	--	--	--	--	--	--	--	1	9
Hedysarm alpinum	--	--	5	3	20	+	5	10	1	1	5	3	--	3	10	1
Luzula parviflora	--	--	5	+	--	--	--	--	--	4	--	--	--	--	--	--
Poa lanata	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--
Calamagrostis canadensis	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--
Calamagrostis neglecta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--
Polygonum alaskanum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--
Bryophytes																
Aulacomnium palustre	20	--	--	--	+	3	--	--	15	4	--	--	--	--	--	--
Dicranum sp.	--	--	10	8	17	2	3	20	--	--	25	12	--	+	1	5
Hylocomium splendens	1	20	--	--	--	--	--	--	--	5	--	--	--	--	--	--
Polytrichum juniperinum	40	--	1	5	5	+	15	5	5	5	10	3	--	--	--	--
Pleurozium schreberi	--	--	--	--	+	--	--	--	--	--	--	--	40	--	1	15
Lichens																
Alectoria ochroleuca	--	--	10	1	18	35	50	10	--	4	+	15	--	+	--	--
Cladina stellaris	35	45	40	55	18	--	--	--	18	30	+	40	--	+	--	20
Cladina rangiferina	5	5	--	--	+	--	--	--	+	2	--	--	--	+	--	10
Cladina mitis	2	--	--	--	--	--	--	--	--	--	10	--	+	1	--	--
Cladonia sp.	+	+	+	+	+	--	+	--	+	1	+	2	--	1	+	7
Cetraria nivalis	--	+	15	10	10	25	40	10	+	15	5	2	--	10	--	--
Cetraria cucullata	--	--	1	--	2	4	5	1	--	4	15	8	--	3	10	6
Cetraria islandica	1	3	+	+	--	--	--	--	--	--	--	1	--	1	--	--
Cetraria richardsonii	+	+	+	--	+	--	--	1	+	1	+	+	--	--	--	--
Stereocaulon sp.	25	--	--	--	2	20	10	5	18	30	20	35	5	30	15	2
Dactylina arctica	1	2	+	+	+	--	+	+	+	1	+	+	--	--	--	+
Nephroma arcticum	--	+	--	--	+	+	--	--	--	--	--	--	+	--	--	--
Peltigera aphthosa	--	+	--	--	+	--	--	--	--	--	--	--	--	+	--	3

Table 4. Site data for four stands in five CT's in the alpine - non-treed subalpine zone in the Macmillan Pass study area. A '*' indicates that a site photo is included in the texts. Species cover data are in Table 5.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth to Water	Depth to Frost	Soil Subgroup	Terrain Type
BEGL-SASP/HYSP CT											
31.	1425.	L	0.	VF	R	SH	P	17.	-.	RG	G$-A.P
63.*	1550.	NE	4.	LS	S	SH	I	10.	13.	RSC	G$-M.B
355.	1585.	W	18.	US	M	M	W	-.	-.	OR	-M.V
444.	1650.	SW	26.	LS	S	SH	I	20.	-.	RG	FB-M.
CATE/DISP-POJU CT											
29.*	1680.	NW	25.	US	M	SM	W	-.	-.	ODYB	RG-C.V
178.	1660.	E	15.	US	M	SX	W	-.	-.		
304.	1565.	L	0.	A	M	M	MI	-.	-.	ODYB	-M.V
439.	1835.	SW	10.	US	M	SM	MW	-.	-.		-C.V
FEAL/POJU CT											
256.	1660.	S	58.	US	R	M	R	-.	-.	EEB	GK-C.B
318.	1620.	NW	0.	MS	M	M	W	-.	-.	EDYB	-M.V
319.	1610.	MI	15.	US	R	M	W	-.	-.	EB	GS-M.B
375.	1520.	S	15.	US	M	SM	MW	-.	-.	ODYB	G$-M.B
FEAL/FORB CT											
43.	1487.	E	50.	MS	M	SH	MI	-.	-.		
71.*	1588.	SW	65.	US	M	M	W	-.	-.	OHFP	RG-C.B
197.	1380.	W	40.	US	M	SM	MW	-.	-.	OHFP	GK-C.B
376.	1490.	S	30.	US	M	M	W	-.	-.	OR	G$-C.V
DRIN/SARE CT											
17.	1650.	SW	50.	MS	M	SM	MW	-.	-.	OEB	R -C.B
61.	1885.	NE	0.	A	M	SM	W	-.	-.	OTC	RS-R.M
62.*	1835.	NE	0.	MS	M	M	MI	-.	25.	RSC	AR-C.V
421.	1785.	SE	44.	US	M	SM	W	-.	-.	OR	R$-C.B

Table 5. Estimated % cover of plant species in four sites in each of five community types in the alpine and non-treed subalpine zones of the Macmillan Pass/Sheldon Lake region. A '--' indicates species absence, a '+' indicates occurence in trace amounts. Site data are presented in Table 4.

	Mesic alpine and non-treed subalpine communities and site numbers																			
	Begl-Sasp/Hysp				Cate/Disp/Poju				Feal/Poju				Feal/Forb				Drin-Sare			
Species	31	63	355	444	29	178	304	439	256	318	319	375	43	71	197	376	17	61	62	421
Trees																				
Abies lasiocarpa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--
Picea mariana	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Erect Shrubs																				
Betula glandulosa	--	12	7	17	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--
Ledum palustre	--	--	--	3	--	--	11	--	--	--	--	--	--	--	--	--	--	--	--	--
Potentilla fruticosa	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix sp.	30	21	13	3	--	--	--	--	--	--	--	4	--	--	--	--	5	--	--	3
Vaccinium uliginosum	--	1	3	15	--	--	1	--	5	--	--	--	--	--	2	--	--	--	--	2
Spiraea beauverdiana	--	--	--	--	--	--	--	--	6	--	--	--	+	--	+	--	--	--	--	--
Rosa acicularis	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--
Prostrate Shrubs																				
Arctostaphylos rubra	--	5	--	--	--	--	--	--	--	--	--	2	--	--	--	1	--	--	--	--
Cassiope tetragona	--	3	4	2	35	15	10	25	--	20	--	20	--	--	--	--	--	--	--	10
Empetrum nigrum	--	--	8	1	--	--	8	--	10	--	--	3	+	--	5	--	--	--	--	--
Salix reticulata	10	7	--	+	--	--	--	--	--	--	--	--	--	--	--	--	30	5	10	10
Vaccinium vitis-idaea	--	--	2	1	--	--	+	+	3	--	--	--	--	--	3	--	--	--	--	2
Phyllodoce empetriformis	--	--	--	--	--	3	--	--	--	2	--	--	--	--	--	--	--	--	--	--
Juniperus communis	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--
Dryas integrifolia	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	15	5	15	5
Salix arctica	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	+	3	--
Forbs																				
Anemone narcissiflora	--	--	--	+	--	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--
Anemone parviflora	--	+	--	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--
Artemisia arcticum	--	--	12	--	--	+	2	--	--	3	5	8	4	8	10	8	+	+	--	--
Dodecatheon frigidus	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lagotis glauca	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lupinus arcticus	+	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	8	--
Mertensia paniculata	--	2	--	--	--	--	--	--	--	--	--	--	2	20	--	+	--	--	--	--
Parrya nudicaulis	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--
Petasites frigidus	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--
Polemonium acutiflorum	--	+	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 5 continued.

	Begl-Sasp/Hysp				Cate/Disp/Poju				Feal/Poju				Feal/Forb				Drin-Sare			
Species	31	63	355	444	29	178	304	439	256	318	319	375	43	71	197	376	17	61	62	421
Senecio lugens	--	+	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--
Antennaria monocephala	--	--	--	--	2	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
Gentiana glauca	--	--	--	--	+	+	+	+	+	+	+	+	--	--	--	--	--	--	--	--
Pedicularis labradorica	--	--	--	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--
Potentilla uniflora	--	--	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Veratrum viride	--	--	--	--	--	+	--	--	--	--	5	--	15	--	--	2	--	--	--	--
Anemone drummondii	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--	--	--	--	--
Anemone multifida	--	--	--	--	--	--	--	--	--	--	--	+	2	--	+	--	--	+	+	--
Polygonum alaskanum	--	--	--	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--
Senecio atropurpureus	--	--	--	--	--	--	--	--	--	2	5	--	--	--	--	1	--	--	--	--
Sibbaldia procumbens	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
Aconitum delphinifolium	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--
Senecio sheldonensis	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
Cornus canadensis	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--	--	--
Epilobium angustifolium	--	--	--	--	--	--	--	--	--	--	--	--	2	30	4	1	--	--	--	--
Myosotis alpestris	--	--	--	--	--	--	--	--	--	--	--	--	+	2	--	+	--	--	--	--
Rubus arcticus	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	+	--	--	--	--
Rumex arcticus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--
Saxifraga tricuspidata	--	--	--	--	--	--	--	--	--	--	--	--	--	1	+	--	--	1	--	--
Sedum rosea	--	--	--	--	--	--	--	--	--	--	--	--	+	1	--	--	--	--	--	--
Senecio triangularis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--
Solidago multiradiata	--	--	--	--	--	--	--	--	--	--	--	--	+	2	--	--	--	--	--	--
Valeriana capitata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--
Valeriana sitchensis	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--
Zygadenous eleg	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--	--	--
Oxytropis maydelliana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
Oxytropis nigricans	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	+	--
Saxifraga flagelis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--
Silene acaulis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	1	--	--
Taraxacum hyparcticum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--
Graminoids																				
Calamagrostis canadensis	5	--	--	--	--	--	--	--	--	--	--	--	--	5	+	--	--	--	--	--
Carex podocarpa	5	--	5	15	--	--	--	--		1	5	+	--	1	1	1	--	--	--	4
Hedysarm alpinum	--	--	--	+	--	--	--	--	10	--	--	--	--	--	--	--	--	--	--	+
Poa lanata	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Festuca altaica	--	--	--	--	3	1	5	--	40	3	10	10	15	65	55	40	--	--	--	--
Luzula parviflora	--	--	--	--	1	+	--	1	--	--	--	+	--	1	--	3	--	--	--	--
Phleum commutatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--
Trisetum spicatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--

Table 5 continued.

Species	Begl-Sasp/Hysp				Cate/Disp/Poju				Feal/Poju				Feal/Forb				Drin-Sare			
	31	63	355	444	29	178	304	439	256	318	319	375	43	71	197	376	17	61	62	421
Pteridophytes																				
Lycopodium alpinum	--	--	--	--	10	5	+	--	--	10	20	3	1	--	1	--	--	--	--	--
Lycopodium selago	--	--	--	+	1	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bryophytes																				
Tomenthypnum nitens	30	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aulacomnium palustre	10	--	--	--	--	--	--	--	--	10	--	--	2	--	--	5	--	+	5	--
Dicranum sp.	--	--	--	5	35	30	50	30	--	1	+	10	--	--	--	--	5	--	--	10
Hylocomium splendens	50	40	18	45	--	--	1	--	10	--	--	2	5	--	+	--	--	--	1	--
Phylonotis fontana	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleurozium schreberi	--	--	15	15	--	--	5	--	--	--	20	3	--	--	+	20	10	--	--	2
Polytrichum juniperinum	--	--	5	--	--	5	30	30	50	65	50	50	12	--	2	20	--	--	--	--
Ptilium crista-castrensi	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rhacometrium lanuginosum	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Drepanocladus sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	30	--	--	--	--
Mnium sp.	--	--	--	--	--	--	--	--	--	--	--	--	15	--	--	--	--	--	--	--
Sphagnum sp.	5	--	--	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+
Lichens																				
Cladina stellaris	--	--	18	5	--	+	--	20	--	5	--	5	--	--	--	--	--	--	--	+
Cladina mitis	--	1	--	15	+	1	--	--	10	--	--	--	--	--	+	--	--	--	--	--
Cladina rangiferina	--	--	--	1	--	+	--	10	1	--	--	--	--	--	--	--	--	--	--	--
Cladonia sp.	--	--	2	1	--	1	+	7	+	+	+	+	+	--	--	--	--	--	--	--
Cetraria nivalis	--	--	--	1	--	10	--	--	--	--	--	--	--	--	--	--	--	2	1	15
Cetraria cucullata	--	+	8	1	--	3	10	6	1	--	--	--	--	--	--	--	+	+	5	--
Cetraria islandica	--	+	--	--	--	1	--	--	--	+	--	--	+	--	--	--	+	--	+	2
Cetraria richardsonii	--	--	1	--	--	--	--	--	+	+	--	+	--	--	--	--	--	+	+	--
Stereocaulon sp.	--	--	+	--	5	30	15	2	15	1	10	30	--	--	--	--	+	--	+	--
Dactylina arctica	--	+	3	+	--	--	--	+	--	+	--	+	--	--	--	--	+	--	+	+
Alectoria ochroleuca	--	--	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	3	5	15
Alectoria nigricans	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--
Nephroma arcticum	--	--	2	--	+	--	--	--	--	2	+	--	--	--	--	--	--	+	--	--
Peltigera aphthosa	--	--	--	--	--	+	--	3	--	--	--	--	--	--	--	--	--	+	--	--

4.3.10 Calamagrostis canadensis/Hylocomium splendens TCT

CL# 1, IS=.452, n=2:3,275

CACA/HYSP is a subalpine community type occurring on gently sloping sites with moderately well-drained Brunisolic soils formed on alluvial materials. Water was present in one soil profile at a depth of 95 cm.

This community is characterized by a high cover of *Calamagrostis canadensis* (30-50%). Forbs, especially *Senecio triangularis* , *Polemonium acutiflorum* and *Epilobium angustifolium* , are common. *Hylocomium splendens* is the dominant bryophyte.

4.3.11 Vaccinium uliginosum/Calamagrostis canadensis TCT

CL# 1, n=1:81

VAUL/CACA is a rarely occurring, submesic, alpine community occurring on a steep, south-facing site. The soil is a rapidly pervious, well-drained Orthic Humo-Ferric Podzol formed on a colluvial veneer.

This type is characterized by the dominance of *Calamagrostis canadensis* (45% cover). *Festuca altaica* is also present with a relatively high cover value. *Vaccinium uliginosum* is the common LS, though *Spiraea beauverdiana* is also present. Forbs are numerous, with *Artemisia arcticum* and *Polygonum alaskanum* being most common; their combined cover value is low (7%). *Tomenthypnum nitens* is the dominant moss though *Hylocomium splendens* also occurs. Lichens are present in trace amounts.

4.3.12 Veratrum viride/Hylocomium splendens TCT

CL# 2, IS=.662, n=2:336,430

VEVI/HYSP is a subhygric, subalpine community occurring on gently to moderately sloping, north-facing sites between 1180 and 1440 m. Soils are slowly to moderately pervious, imperfectly to moderately well-drained Eluviated Eutric Brunisols, and Rego Humic Gleysols, formed on morainal blankets. The ground is covered by an almost continuous bryoid mat; *Hylocomium splendens* is dominant, though *Polytrichum juniperinum* and *Aulacomnium* sp. are common. *Dicranum* sp. and *Pleurozium schreberi* may also occur. *Veratrum viride* is the most common forb, though *Epilobium angustifolium* , *Artemisia arcticum* , *Senecio triangularis* , and *Valeriana capitata* also occur. Total forb coverage exceeds 30%. *Festuca altaica* and *Luzula parviflora* are the dominant graminoids. Total graminoid cover is 10 to 20%. Lichens are rare.

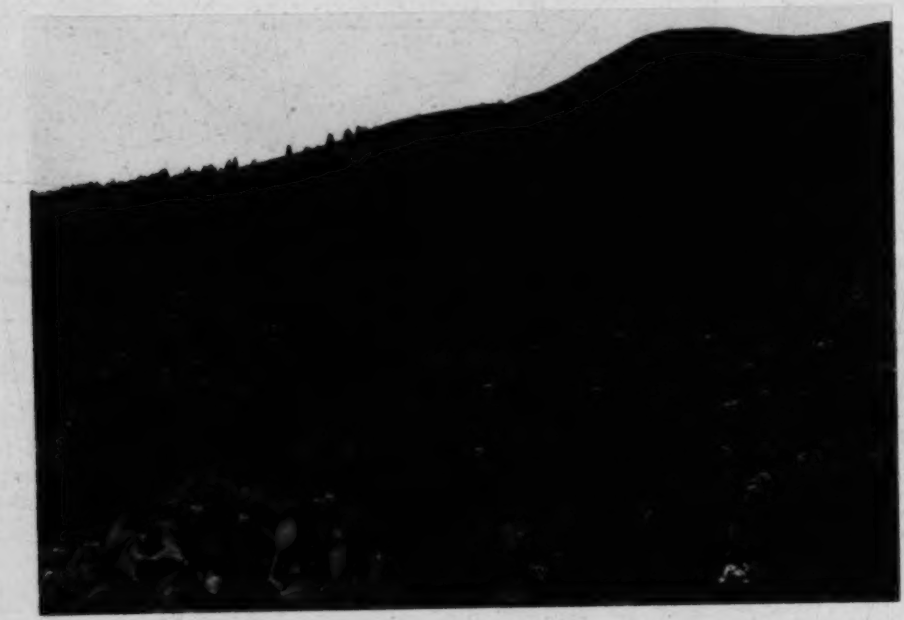


Plate 11. VEVI/HYSP TCT, Site 336, West of Itsi Mtn. (62° 45′ 60″ N, 130° 47′ 50″ W). Soil is a poorly drained R.HG, occurring on a morainal blanket. Elevation - 1185 m. This is a forb-dominated site with 17 species present, *Veratrum viride* and *Valeriana sitchensis* are dominant (10% cover). Date sampled - July 29, 1981.

4.3.13 Cassiope tetragona/Hylocomium splendens TCT

CL# 2, IS=.885, n=2:190,426

CATE/HYSP is mesic alpine community occurring on steep, northerly-facing upper slopes. Parent materials are colluvium with moderately well-drained, moderately pervious Brunisolic and Regosolic soils.

This community is characterized by a high cover of *Hylocomium splendens* (70-80%). It is floristically distinguished from the other communities in Cluster 2 by the relatively high cover of *Cassiope tetragona* (20-30%) and *Arctostaphylos rubra* (12-15%). Fruticose lichens occur, but with a very low cover. *Nephroma arcticum* occurs with a cover value of 4-10%. Forbs are common (10-30%), with *Artemisia arcticum* and *Mertensia paniculata* occurring most often.

4.3.14 Cassiope tetragona/Festuca altaica TCT

CL# 4, IS=.196, n=3:26,220,221

CATE/FEAL is typically a submesic to subxeric alpine community occurring on level to moderately sloping southerly sites, between 1670 and 1770 m. Soils are usually moderately well to rapidly drained Brunisols, formed on colluvial or morainal material. Exposed soil and rocks are common. The pH of the rooting zone is extemely to very strongly acidic (4.4-4.9).

Within the community, *Cassiope tetragona* and *Festuca altaica* are codominants, with 10-20% cover. *Lycopodium* spp. always occur but with a low cover value. *Dicranum* sp. is the common moss, though it has a low cover value. *Polytrichum juniperinum* may occur. Fruticose lichens are present in trace amounts. *Luzula parviflora* and *Carex podocarpa* may be present in trace amounts. *Artemisia arcticum* and *Gentiana glauca* are the common forbs.

4.3.15 Salix sp.-Betula glandulosa/Festuca altaica TCT

CL# 4, n=1:222

This is a submesic, subalpine community occurring on steep south-facing slopes. Soils are rapidly pervious, rapidly drained Brunisols. pH of the rooting zone is extremely acidic.

This community is differentiated from the other *Festuca altaica* communities by the relatively high cover of MS *Betula glandulosa* and *Salix* sp. (15-20%). Common prostrate shrubs are *Juniperus communis* (15%) and *Empetrum nigrum* (10%). *Pleurozium schreberi* and *Dicranum* sp. occur but with a low cover value. Fruticose lichens occur in trace amounts. Common forbs are *Artemisia arcticum* and *Epilobium angustifolium* . Total forb cover does not exceed 10%.

4.3.16 Salix sp./Festuca altaica TCT

CL# 3, n=1:72

This is a disturbed, subalpine community occurring on steep south facing-slopes at the bottom of snow-avalanche chutes. Though represented here by a single site, it is rather common in the north half of the study area. The soils are moderately well-drained, Orthic Dystric Brunisols formed on bedrock,

MS *Salix* sp. is the dominant species (40%). *Festuca altaica* , *Juniperus communis* , and *Hylocomium splendens* are codominants (10%)in the understory. Common forbs are *Epilobium angustifolium* , *Mertensia paniculata* and *Artemisia arcticum* . Total forb cover is ca. 15%.

4.3.17 Ericaceous Shrub/Festuca altaica/Pleurozium schreberi TCT

CL# 5, IS=.275, n=3:126,168,230

ERIC/FEAL/PLSC is a mesic subalpine community occurring on steep, southerly-facing slopes. Soils are moderately to rapidly pervious, moderately to well-drained Orthic Dystric Brunisols and Ortho Regosols, formed on colluvial material. The pH of the rooting zone ranges from extemely to very strongly acidic (4.0-4.9).

The dominant non-vascular species within this community type is *Pleurozium schreberi* , with a cover of 20-50%. *Polytrichum juniperinum* or *Tomenthypnum nitens* may also be present with a relatively high percent cover. Total bryophyte cover ranges from 40 to 70%. *Vaccinium vitis-idaea* and *Empetrum nigrum* are the common ericaceous shrubs, with cover values of 6-50%. *Festuca altaica* has 100% constancy with cover values ranging from 5 to 25%. Forbs are common, with *Artemisia arcticum* always being present but, total forb coverage does not surpass 15%. Cladinae lichens are rare, but *Stereocaulon* sp. may attain a relatively high cover value (15%).

4.3.18 Carex podocarpa/Pleurozium schreberi TCT

CL# 5, n=1:341

This is a mesic subalpine community occurring on gently sloping seepage sites. The soil is a moderately well-drained, moderately pervious Ortho-Humic Regosol formed on an alluvial apron.

The dominant species is *Pleurozium schreberi* with 70% cover. Graminoids dominate the vascular flora (60%), with *Carex podocarpa* being most common. *Arctagrostis latifolia* and *Festuca altaica* also attain a relatively high cover value (10-15%). Forbs are numerous with *Polemonium acutiflorum* and *Aconitum delphinifolium* achieving the highest cover value (5%). Total forb cover is ca. 15%. Lichens are absent or rare.

4.3.19 Salix sp./Pleurozium schreberi TCT

CL# 5, IS=.569, n=2:88,298

This is a subhygric, subalpine community occurring on gentle north slopes. Elevation is ca. 1550 m. The soils are moderately well-drained Cryosols, formed on morainal material.

SASP/PLSC is dominated by a bryoid mat. *Pleurozium schreberi* is the dominant bryophyte (30-45% cover); *Dicranum* sp. and *Polytrichum juniperinum* are common (15-30%). Total lichen cover varies from 13 to 38 %, with *Cladina stellaris* being most common. TS and MS Salix are common shrubs (ca. 20% cover). *Betula glandulosa* , *Empetrum nigrum* and *Cassiope tetragona* also occur. Common graminoids are *Festuca altaica* , *Carex podocarpa* and *Calamagrostis canadensis* . Total graminoid cover ranges from 9 to 19 %. Common forbs, present in trace amounts, are *Rubus chamaemourus* , *Artemisia arcticum* , and *Pedicularis labradorica* .

4.3.20 Salix sp./Carex aquatilis/Pleurozium schreberi TCT

CL# 5, n=111

SASP/CAAQ/PLSC is a hygric, subalpine community occurring on a gently sloping, valley floor seepage site, with poorly drained Organic soils. Water was present in the soil profile at a depth of 100 cm.

Bryophtes are the dominant species with *Pleurozium schreberi* having a cover of 60%. *Aulacomnium palustre* , *Sphagnum* sp. , .*Hylocomium splendens* , and several leafy liverworts also occur. *Carex aquatilis* is the dominant vascular species with 50% cover. MS *Salix* sp. has a cover of 25%. Brown (1983) stated that *Salix glauca* is the most common willow in this type, while Porsild (1951) stated that *S. barrattiana* is common in such habitats. Common forbs are *Veratrum viride* , *Valeriana spp.* , and *Senecio triangularis* . Their combined cover value is ca. 10%. Lichens are absent.

4.3.21 Carex aquatilis/Moss TCT

CL# 7 & 8, IS=.130, n=3:4,12,20

CAAQ/MOSS is a subhydric, subalpine community type occurring at or near timberline on level to very gently sloping valley floors, between 1180 and 1375 m. Soils are very poorly to imperfectly drained Fibrosols, formed on organic parent materials.

CAAQ/MOSS is a species-poor community characterized by a high cover of *Carex aquatilis* (40-60%). Either *Sphagnum* sp. or *Tomenthypnum nitens* is the dominant bryophyte. Other bryophytes which may be present are *Aulacomnium* sp. , *Hylocomium splendens* , *Paludella squarrosa* , and *Campanula stellaris* . Total bryophyte cover often equals 100%. Occassional MS and LS *Salix* sp. may be present.

4.3.22 Betula glandulosa/Cladina stellaris-Stereocaulon sp. TCT

CL# 9, IS=.604, n=2:60,215

BEGL/CLST-STSP is a subalpine community occurring just above treeline on level sites between 1220 and 1250 m. Soils are rapidly to very rapidly drained, Eluviated Dystric Brunisols, formed on glacio-fluvial or morainal parent material. The pH of the rooting zone is extremely acidic.

This community is dominated by lichens (80-95%). The most prominent lichen, *Cladina stellaris* has a cover of 40-50%, while the cover of *Stereocaulon* sp. ranges from 25 to 30%. Total bryophyte cover values are highly variable, ranging from 15-70%; with *Pleurozium schreberi* and *Polytrichum juniperinum* being dominant. *Betula glandulosa* is present in either the TS, MS, or LS stratum with cover range of 25-30%. *Cassiope tetragona* is absent, which distinguishes this community from the CATE/CLST CT, which occurs at higher elevations. BEGL/CLST-STSP is very similar to BEGL/CLST which occurs below treeline.

4.3.23 Betula glandulosa/Cladina stellaris-Hylocomium splendens TCT

CL# 9, n=1:13

BEGL/CLST-HYSP is a rare subalpine community found on a moderately, sloping east-facing site, at 1525 m. The soil is an imperfectly drained, moderately pervious Brunisolic Static Cryosol. Frost was found in the soil profile at 90 cm. The pH of the rooting zone is extremely acidic (4.0).

This community is characterized by the high cover of *Cladina stellaris* (40%), and *Hylocomium splendens* (30%). *Betula glandulosa* is the dominant shrub, though *Salix*sp., *Cassiope tetragona* , and other ericaceous shrubs occur. *Festuca altaica* is a common graminoid. This type is distinguished from the BEGL/CLST-STSP community by the high cover of *Hylocomium splendens* and the absence of *Stereocaulon* sp. .

4.3.24 Cladina stellaris-Alectoria ochroleuca TCT

CL# 9, IS=.567, n=3:95,151,240

CLST-ALOC is a submesic, alpine community occurring on gently sloping southeast-facing slopes or level sites between 1370 and 1560 m. Soils are typically moderately pervious, well-drained Orthic Dystric Brunisols, occurring on morainal or bedrock parent materials. The pH of the rooting zone ranges from extremely to very strongly acidic (3.8-4.7).

This is a lichen-dominated community distinguished by a high cover of *Cladina stellaris* (30-50%). *Stereocaulon* sp. may also be present with a high cover. *Alectoria ochroleuca* is always present, with a cover range of 10-25% (x=20%). Total lichen cover values exceed 60% and may be as high as 85%. Ericaceous shrubs ~~are~~ common, with *Vaccinium vitis-idaea* being most plentiful with a cover of 5-15%. Graminoids, which are often represented by *Hierochloe alpina* , have a modest cover, never exceeding 15%, and usually much lower. There is a low diversity of forbs, and those present occur in trace amounts.

4.3.25 Cassiope tetragona/Polytrichum juniperinum TCT

CL# 11, IS=.538, n=3:69,135,452

CATE/POJU is an alpine community occurring on submesic, gently to steeply sloping, north-facing sites between 1430 and 1560 m. Soils are typically moderately well to well-drained Brunisols and Regosols formed on colluvium.

This community is characterized by a very high cover of *Cassiope tetragona* (40-50%), which distinguishes it from the other CATE communities. *Vaccinium vitis-idaea* , the only other ericaceous shrub present, occurs in trace amounts. Cover of bryophytes and lichens varies considerably. Bryophytes usually have the higher cover value. *Polytrichum juniperinum* occurs with both a high constancy and high cover value (8-25%). *Dicranum* sp. may be present, but never with the high cover values found in the CATE/DISP-POJU CT. *Aulacomnium palustre* may also have a high cover. Lichens are represented by a the fruticose *Cladina stellaris* , and foliose *Nephroma arcticum* , both of which occur with high constancy, and occasionally high cover. Graminoids are represented by low covers of *Festuca altaica* and *Calamagrostis canadensis* .

4.3.26 Empetrum nigrum/Polytrichum juniperinum TCT

CL# 16, n=1:50

This is a rare, mesic subalpine community situated on a northeast-facing, gently sloping glacio-fluvial terrace, with a Orthic Humo-Ferric Podzol soil. It occurs near the upper limit of treeline at 1370 m.

This community is characterized by a high cover of *Polytrichum juniperinum* (35%), *Cladina stellaris* (15%), *Empetrum nigrum* (20%), and *Cassiope tetragona* (15%). It is differentiated from the other CATE community types by the high cover of *Empetrum nigrum* . Ericaceous shrubs, if present, occur in trace amounts. Other bryophytes present are *Pleurozium schreberi* and *Aulacomnium* sp. . Numerous other lichens are present in trace amounts. Graminoids are represented by a low cover of *Luzula parviflora* .

4.3.27 Hierochloe alpina/Polytrichum juniperinum TCT

CL# 16, n=1:279

This is a north-facing, moderately sloping, alpine site that has been recently burned. The ground is dominated by *Polytrichum juniperinum* (40%). *Hierochloe alpina* is the dominant graminoid. *Calamagrostis canadensis* is present. The remaining flora consists of low amounts of *Vaccinium vitis-idaea* , *Vaccinium uliginosum* , *Betula glandulosa* , *Spiraea beauverdiana* and *Epilobium angustifolium* . Exposed charred soil and rock are present.

4.3.28 Lycopodium alpinum-Aulacomniun palustre sp. TCT

CL# 6, n=1:32

LYAL-ALPA is a rare alpine community type occurring on a gently-sloping, south-facing site at 1685 m. The soil is a well drained Orthic Humo-Ferric Podzol developed on a morainal veneer.

The site is characterized by a high cover of *Aulacomnium palustre* (50%), *Lycopodium alpinum* (30%), and a single ericaceous shrub, *Phyllodoce empetriformis* (20%). *Luzula parviflora* is the dominant graminoid (10%). Lichens and forbs are present in trace amounts.

4.3.29 Senecio triangularis / Aulacomnium palustre TCT

CL# 6, n=1:179

This is a rare forb meadow community occurring on an imperfectly drained seepage site on an alpine valley floor at 1800 m.

This community is characterized by an extremely high cover of *Senecio triangularis* (75%). Other forbs with moderately high cover values are *Valeriana capitata* , *Veratrum viride* , and *Polemonium acutiflorum* . Lichens and ericaceous shrubs are absent.

4.3.30 Carex podocarpa/Aulacomnium palustre TCT

CL# 6, n=1:422

CAPO/AUPA is a rarely-occurring subhygric alpine community found on a moderately-sloping north-facing site. The soil is an imperfectly drained Ortho Regosol, developed on a colluvial veneer. The pH of the rooting zone is strongly acidic (5.2), but less so than the majority of alpine soils.

This is a bryophyte-dominated community where *Hylocomium splendens* and *Aulacomnium palustre* are codominants, each having 25% cover. *Carex podocarpa* is the dominant graminoid with 20% cover. *Polygonum alaskanum* , *Eriophroum angustifolium* , and *Hierochloe alpina* are present in trace amounts. *Polygonum bistorta* and *Oxytropis maydelliana* are the common forbs, occurring with a relatively high cover value for forbs (5-8%). *Alectoria ochroleuca* and *Cetraria cucullata* are the dominant lichens but have low cover values.

4.4 DECORANA Ordination Results

The 106 stands plotted against the X and Y axes of the DECORANA ordination are shown in Figure 3. A diagrammatic model illustrating the relationships between the ordination axes and their correlated environmental variables is shown in Figure 4. Site coordinates on the X and Y axes are given in Appendix VII. All environmental variables discussed below are significantly correlated at alpha=.05. Soil variables discussed below are taken from the rooting zone only.

The X-axis represents a complex-gradient, which accounts for 67% of the variation in the vegetation data. It is strongly negatively correlated with soil drainage (r=-.60*) and ecological moisture (r=-.68*), which are strongly correlated with each other. It is positively correlated with the soil pH (r=+.22), % clay (r=+.46), Ca (r=+.33), and Mg (r=+.32).

The Y-axis, accounting for 40% of the residual variation, or 13% of the total variation is weakly, negatively correlated with slope x aspect (r=-.27*) and the C/N ratio (r=-.34*).

The Z-axis accounts for 30% of the residual variation, or 6% of the total variation. It too represents a complex-gradient with which aspect (r=-.29) and slope x aspect (r=-.43), are weakly correlated.

The fourth axis accounts for 24% of the residual variation, but only 3% of the total variation and is therefore not used.

There is considerable overlap of the clusters when drawn on the X-Y ordination field (Fig 3). The communities which are dominated by lichens and submesic mosses (*Dicranum* sp. ,*Polytrichum juniperinum*), occupy similar positions along the X-axis, but different, but overlapping, positions along the Y-axis. SHRUB/ALEC occurs nearest the origins of the X and Y-axis; it overlaps with the SHRUB/STSP community, which, in turn, overlaps with the *Cladina stellaris* -dominated cluster. The communities within this latter cluster, which have *Stereocaulon* sp. or *Alectoria ochroleuca* as the secondary lichen, overlap with either SHRUB/ALOC or SHRUB/STSP. The CATE/CLST community overlaps with the CATE/DISP, FEAL/POJU, and the CATE/POJU communities which occur above it on the Y-axis. This suggests that all these communities have a similar tolerance to soil drainage conditions, but that the CATE/DISP, FEAL/POJU, and CATE/POJU communities prefer cool northerly slopes. Figure 6 illustrates the slope-aspect relationships of the major communities.

Along the X-axis, the lichen communities intergrade into those dominated by feathermosses, forbs, or graminoids. *Carex aquatilis* dominated communities lie at the far end of the X-axis.

The clusters with the lowest within-cluster similarity indices (IS values) tend to have the widest amplitude on the X and/or Y-axis. Cluster 16 (IS=.423) has one of the highest similarity indices and occupies the ordination field at the dry (near) end of the X-axis, halfway up the Y-axis; its amplitude on both axes is relatively narrow. This is in contrast to Cluster 1 (IS=.343), which has a very narrow amplitude on the X-axis, indicating that the dominant species in the cluster have a narrow range of tolerance to those environmental variables represented by the X-axis, but a very wide amplitude on the Y-axis.

Cluster 2, which is dominated by *Hylocomium splendens* , has one of the lower indices of similarity (IS=.118). It has a wide amplitude on both axes, occurring in the middle of the ordination field, in the mesic to subhygric range of the moisture gradient. This cluster contains one CT and two TCT's, one of which, VEVI/HYSP (IS=.662), lies at the top of the cluster and has a narrow amplitude on both the X and Y-axis.

Figure 7 shows the geometric centers of the species on the X-Y field of the DECORANA ordination. These locations of the species on the ordination field are similar to those of the clusters in which these species are dominant. The lichen species occur near the origin of the X and Y-axis, indicating that they usually occur on well-drained, level or southerly-facing sites. This is confirmed by the Chi-square tests of independence (Table 6).

Cassiope tetragona occurs higher on the Y-axis than do the other common ericaceous shrubs, *Vaccinium vitis-idaea* and *Vaccinium uliginosum* . The Chi-square tests of independence demonstrate that *Cassiope tetragona* occurs more often than expected on northerly sites, while the two *Vaccinium* spp. occur more often than expected on southerly facing sites, though all three species can be found on all aspects (Table 7).

Table 8 shows the relationship between the major forbs and associated environmental variables.

Carex aquatilis and its associated fen species lie at the far end of the X-axis, where moisture, pH, and nutrient values are high.

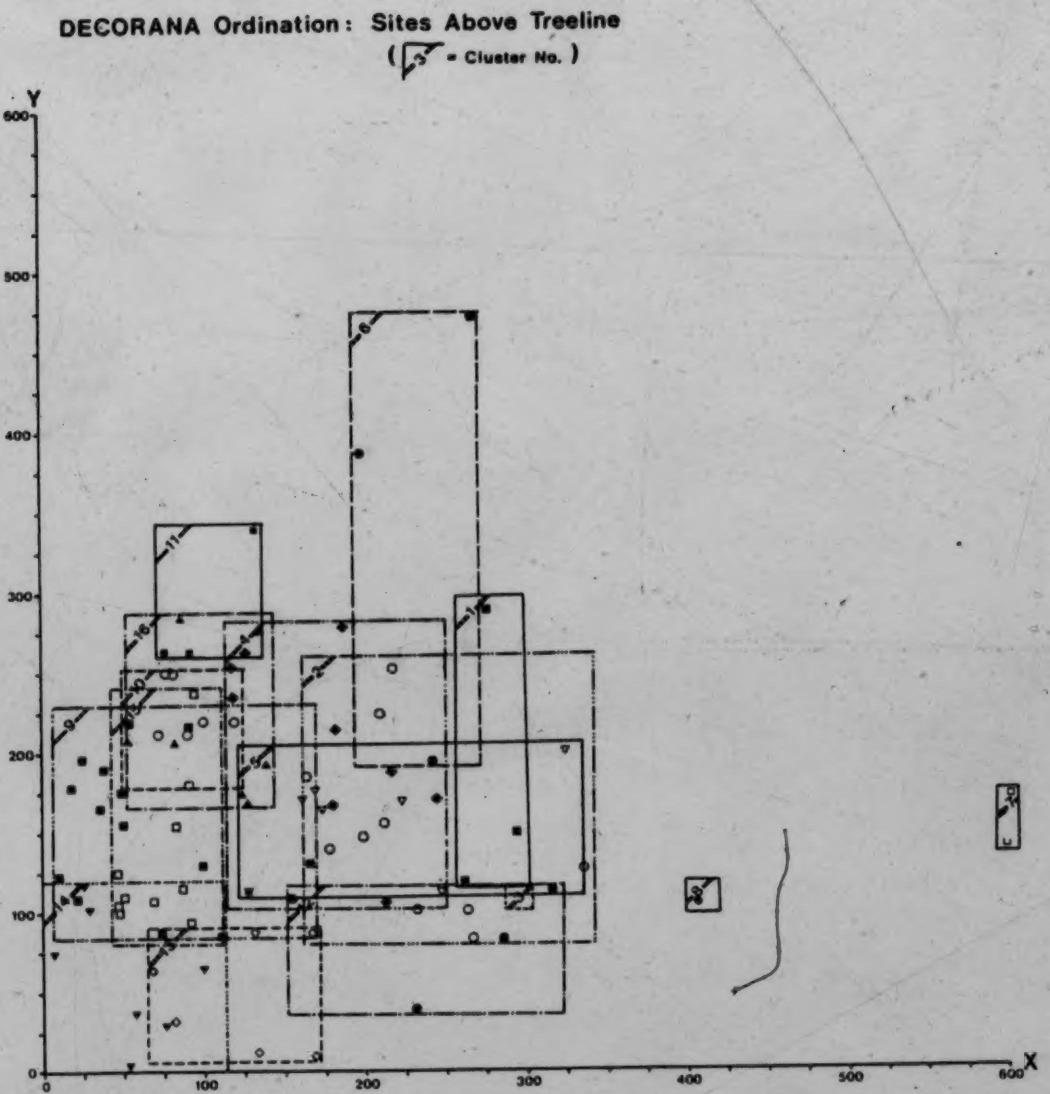


Figure 3. Location of the 106 sites and 16 clusters arising from the cluster analysis on the DECORANA ordination field. The axis units are in average standard deviations of species turnover or SD. Site coordinates are on the axes are in Appendix Vi.

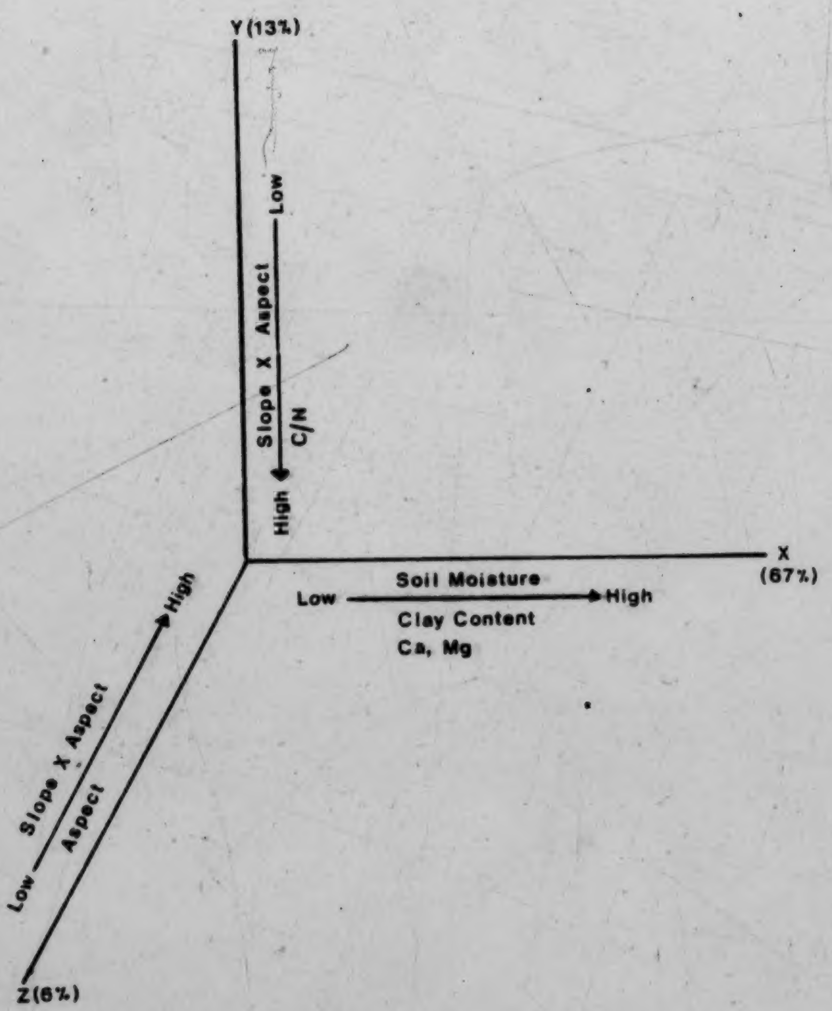

Y(13%)
Low
Slope X Aspect
C/N
High
X
(67%)
Soil Moisture
Low
High
Clay Content
Ca, Mg
High
Slope X Aspect
Aspect
Low
Z(6%)

Figure 4. A diagramatic representation of the first three axis of the DECORANA ordination and the correlated environmental variables - alpine and non-treed subalpine zone. The numbers in parenthesis are the axes eigenvalues , which indicate the amount of variation in the data accounted for by each axis.

DECORANA Ordination: Community Types Above Treeline

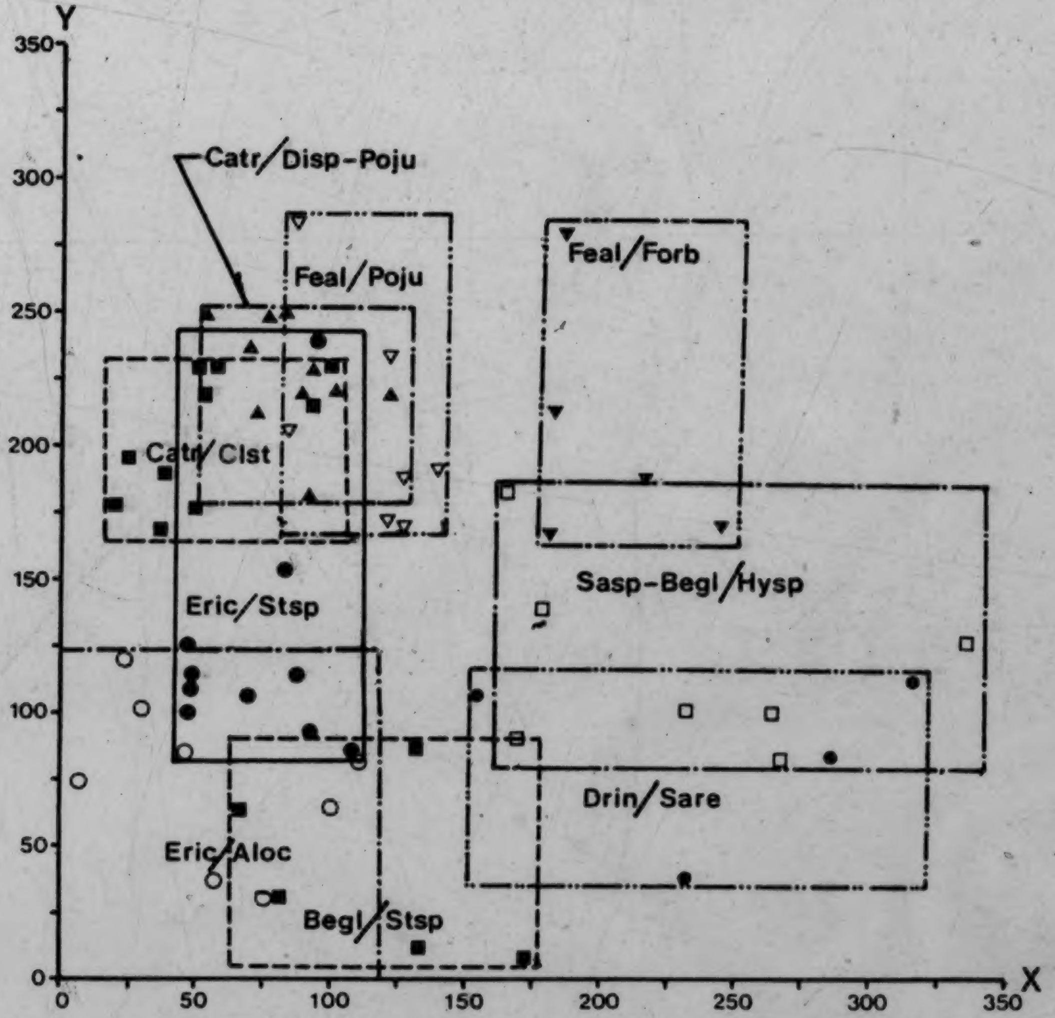
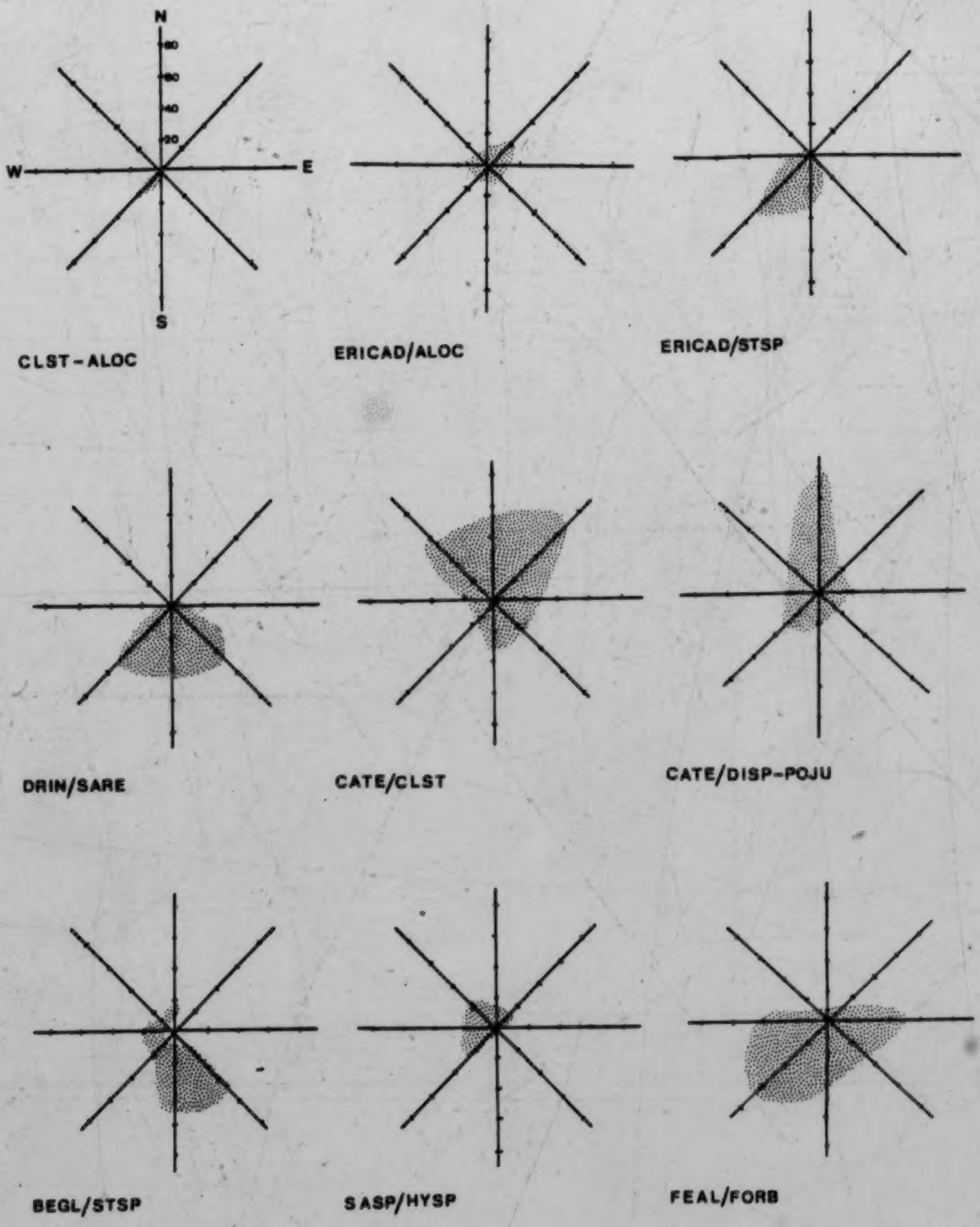


Figure 5. The major alpine and non-treed subalpine community types and sites within these CT's in the DECORANA ordination field. Axes scales are in units of average standard deviation of species turnover.



CLST-ALOC

ERICAD/ALOC

ERICAD/STSP

DRIN/SARE

CATE/CLST

CATE/DISP-POJU

BEGL/STSP

SASP/HYSP

FEAL/FORB

Figure 6. The aspect and slope (%) distribution of 8 CT's and 1 TCT in the alpine and non-treed subalpine zone. Shaded areas represent the range of aspect and slope steepness of sites within the community.

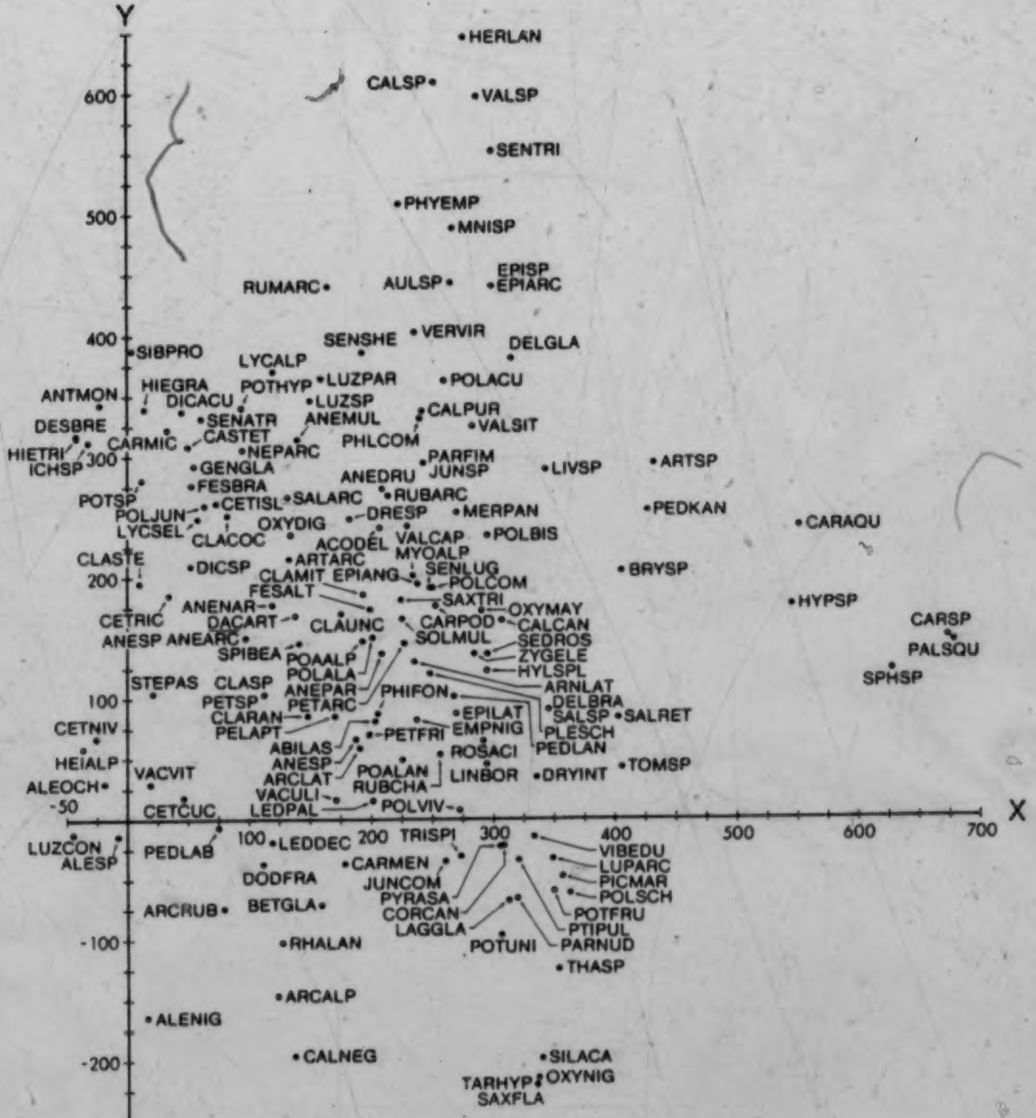


Figure 7. DECORANA Ordination of species in the 106 sites located in the alpine and non-treed subalpine zones. Labels are the first three letters of the genus and species. Complete species names are in Appendix V. Axes scales are in units of average standard deviations of species turnover.

	Soil G.G.		Parent Material		Soil Drainage		Slope		Position		Aspect	
Aloc	I		D	Bedrock	I		D	level moderate	D	Apex	I	
Stsp	D	Brunisols	D	Morainal Bedrock	I		I		D	Upper slope Apex	I	
Clst	I		D	Morainal Glacio-fluvial	I		I		I		I	
Clml	I		I		I		I		I		I	
Clra	I		I		D	rapidly	I		I		I	
Near	I		I		I		I		I		D	north northwest
Hysp	D	Cryosols	I		D	imperfectly mod well	I		I		I	
Plsc	D	Brunisols Regosols	I		I		D	moderate steep	I		I	

Table 6. Chi-square Test of Independence - Alpine Bryophytes and Lichens.
I - indicates that the species occurs independently of the environmental factor.
D - indicates that the species distribution is not independent. While it usually occurs across a range of site factors it occurs more often than expected on the listed factors.

	Soil G.G.		Parent Material		Soil Drainage		Slope	Position		Aspect	
Begl	I		I		D	rapidly imperfectly		I		I	
Sasp	D	Cryosols	I		D	imperfectly poorly	I	D	lower slope valley floor	I	
Cate	I		D	Colluvium Glacio-fluvial	I		I	D	Apex upper slope mid slope	D	northwest north east
Vaul	I		I		I		I	I		D	southwest south southeast
Vavi	I		I		D	well-rapidly	I	D	Apex Upper slope	D	southwest south southeast level
Emni	I		I		I		I	I		I	

Table 7. Chi-square Test of Independence - Alpine Shrubs.

I - indicatates that the species occurs independantly of the environmental factor.

D - indicates that the species distribution is not independant. While it usually occurs across a range of site factors it occurs more often than expected by chance on the listed factors.

	Soil G.G.		Parent Material		Soil Drainage		Slope		Position		Aspect	
Arac	I		I		D	mod well well	D	steep	D	Apex upper slope	I	
Vevi	I		I		I		D	moderate	I		D	east
Gegl	D	Brunisols	I		I		I		D	Apex upper slope	I	
Setr	D	Gleysols Regosols	D	Alluvium	D	mod well poorly	I		D	mid, lower slope valley floor	I	
Luar	I		I		I		I		I		I	
Capo	I		I		D	mod well	I		I		I	
Feel	I		I		I		I		I		D	west southwest south
Heal	I		D	Bedrock	D	rapid well	I		D	Apex Upper slope	I	

Table 8. Chi-square Tests of Independence - Major Alpine Forbs and Grasses
I - indicates that the species occurs independently of the environment factor.
D - indicates that the species distribution is not independent. While it usually occurs across a range of site factors it occurs more often than expected by chance on the listed factors.

5. Forest Communities

5.1 Overview of Forest Sites

The forest communities of the Macmillan Pass study area are found from the valley bottoms at 600 m to the upper limits of tree line at 1600 m. The majority of the forest sites were located on level to strongly sloping (0-40%) morainal, colluvial, alluvial or glacio-fluvial sites, with predominantly imperfectly to well-drained Brunisolic and Cryosolic soils. Out of a total of 192 soil profiles, 39 had a water table present at a depth of 1 to 85 cm, and 78 had frost present at depths of 6 to 90 cm.

The flora of the 246 sites consists of 144 vascular species in 62 genera, and 50 non-vascular species in 21 genera. In terms of major growth-forms, there are 7 trees, 24 erect shrubs, 12 prostrate shrubs, 64 forbs, 25 graminoids, 12 pteridophytes, 20 lichens and 30 bryophytes. The major tree species in the study area are *Picea glauca, P.mariana,* and *Abies lasiocarpa*, with *Populus balsamifera, P.tremuloides*, and *Betula occidentalis* occurring occasionally. Major erect shrubs are *Betula glandulosa, Ledum palustre, Salix* spp. and *Vaccinium uliginosum*. *Salix glauca* and *S. planifolia* are the willows commonly associated with *Picea mariana* ; *Salix longistylis* and *S. bebbiana* are commonly associated with *Picea glauca* ; and *S.barclayi* and *S. longistylis* are commonly associated with *Abies lasiocarpa* . *Salix scouleriana, S. planifolia*, and *S. arbusculoides* are common on burnt-over lands (Porsild 1951). Other less common erect shrubs are *Betula occidentalis, Juniperus communis, Shepherdia canadensis, Spiraea Beauverdiana*, and *Rosa acicularis*. The two most common prostrate shrubs are *Empetrum nigrum* and *Vaccinium vitis-idaea*. Less common are *Arctostaphylos rubra, Cassiope tetragona, Linnaea borealis*, and *Oxycoccus microcarpus*.

Ground cover on the forest floor is dominated by lichens and bryophytes, except for some burns, where forbs dominate. The most commonly occurring fruticose lichen is *Cladina stellaris*, followed by *C.mitis* and *C.rangiferina*. The most commonly occurring foliose lichens are *Peltigera aphthosa* and *Nephroma arcticum*. Commonly occurring bryophytes are *Hylocomium splendens, Pleurozium schreberi, Polytrichum juniperinum, Sphagnum* and *Aulacomnium palustre*.

Grasses and sedges occurred infrequently within the forest stands. The most frequently occurring species were *Arctagrostis latifolia, Calamagrostis canadensis, Festuca altaica,* and *Carex aquatilis*.

A complete constancy list of the vascular and non-vascular species recorded in the stands is found in Appendix V. Undoubtedly there are more species in the forest vegetation, but these unrecorded species are rare. There are probably more unrecorded non-vascular species than vascular ones.

5.2 Cluster Analysis of Stands

Results of the SAHN complete linkage cluster analysis appear in Figure 8. Species deleted from the cluster analysis were those which occurred in trace amounts (<1%) in fewer than 10% of the sites sampled. A total of 155 species were used. Locations of the 21 resulting clusters on the DECORANA ordination are shown in Figures 10 -12. Since environmental factors may vary within a cluster each cluster may contain several distinct community types (CT's) or subtypes (ST's). Groups of four or more sites are recognized as community types, whereas smaller groups are regarded as tentative community types (TCT's). Twelve CT's and 9 TCT's were recognized in the forest zone. Site and species cover data for four sites in each of the major community types are presented in Tables 9 - 14.

Clusters 1-8, and 14 consist of mature forested sites, where the major separation among clusters is based on ground cover.

Cluster 1 is a tight cluster (IS=.410) consisting of 19 mostly subalpine sites. The ground cover is dominated by *Hylocomiun splendens. Abies lasiocarpa* is the dominant tree species, occurring in one or more of the MS, TS, LT or TT strata.

Cluster 2 (IS==.284) is a group of 51 sites, in which the tree stratum is dominated by either *Picea glauca* or *P. mariana*. Ground cover is dominated by *Hylocomiun splendens*. The MS stratum is dominated by *Salix* sp. . *Empetrum nigrum* is the most common prostrate shrub.

Cluster 3 (IS=.195) consists of 28 mesic to submesic, open-structured stands, occurring predominantly at low elevations on valley floors. They are characterized by a high cover of *Cladina stellaris*. The MS stratum is dominated by *Betula glandulosa*. The

TT stratum consists of *Picea mariana* or *Abies lasiocarpa*.

Cluster 4 (IS=.114) contains 7 loosely related sites, characterized by a high cover of *Empetrum nigrum*. Four stands are high elevation subalpine sites where *E. nigrum* is the dominant species in the ground cover stratum, and *Abies lasiocarpa* is the dominant tree species. The other three stands have a similar species composition but occur on vastly different sites. One stand is a low elevation burn where the ground cover is dominated by *E. nigrum*; regeneration is *Picea mariana*. One stand occurs on a level, low elevation site, with organic soils, where lichens occur on dry microsites above the mosses. The third site occurs on a valley floor and is dominated by *Empetrum nigrum*, with *Picea mariana* in the TT stratum.

Cluster 5 (IS=.241) consists of 18 sites dominated by *Sphagnum* spp. and *Cladina stellaris*.

Cluster 6 (IS=.178) consists of 25 predominantly subhygric to mesic sites. Ground cover is dominated by *Pleurozium schreberi* and *Sphagnum* sp.. At low elevations *Picea mariana* is the dominant tree species, while at higher elevations it is replaced by *Abies lasiocarpa*. *Ledum palustre* normally dominates the LS stratum.

Cluster 7 is a loose association (IS=.167) of predominantly mesic sites characterized by a high cover value of *Pleurozium schreberi*. *Betula glandulosa* dominates the MS stratum, with *Picea glauca, P. mariana* or *Abies lasiocarpa* dominating the tree stratum.

Cluster 10 (IS=.097) consists of 11 loosely linked, subalpine sites. Ground cover is dominated by *Empetrum nigrum* and *Polytrichum juniperinum*. *Abies lasiocarpa* is the dominant tree species occurring in the MS, TS, or TT strata.

Cluster 11 (IS=.149) consists of 17 predominantly mesic subalpine sites. Ground cover is normally dominated by *Pleurozium schreberi*, though in three stands leafy liverworts and Cladinae lichens are dominant, and in one stand *Nephroma arcticum* is dominant. These four stands split off the main cluster at IS=0.15.

Cluster 14 (IS=.303) consists of two alluvial sites where *Ptilium crista-castrensis* has a very high cover value. *Picea glauca* is dominant in the TT stratum.

Clusters 8, 9, 12 and 13 are recently burned-over sites grouped into loose clusters.

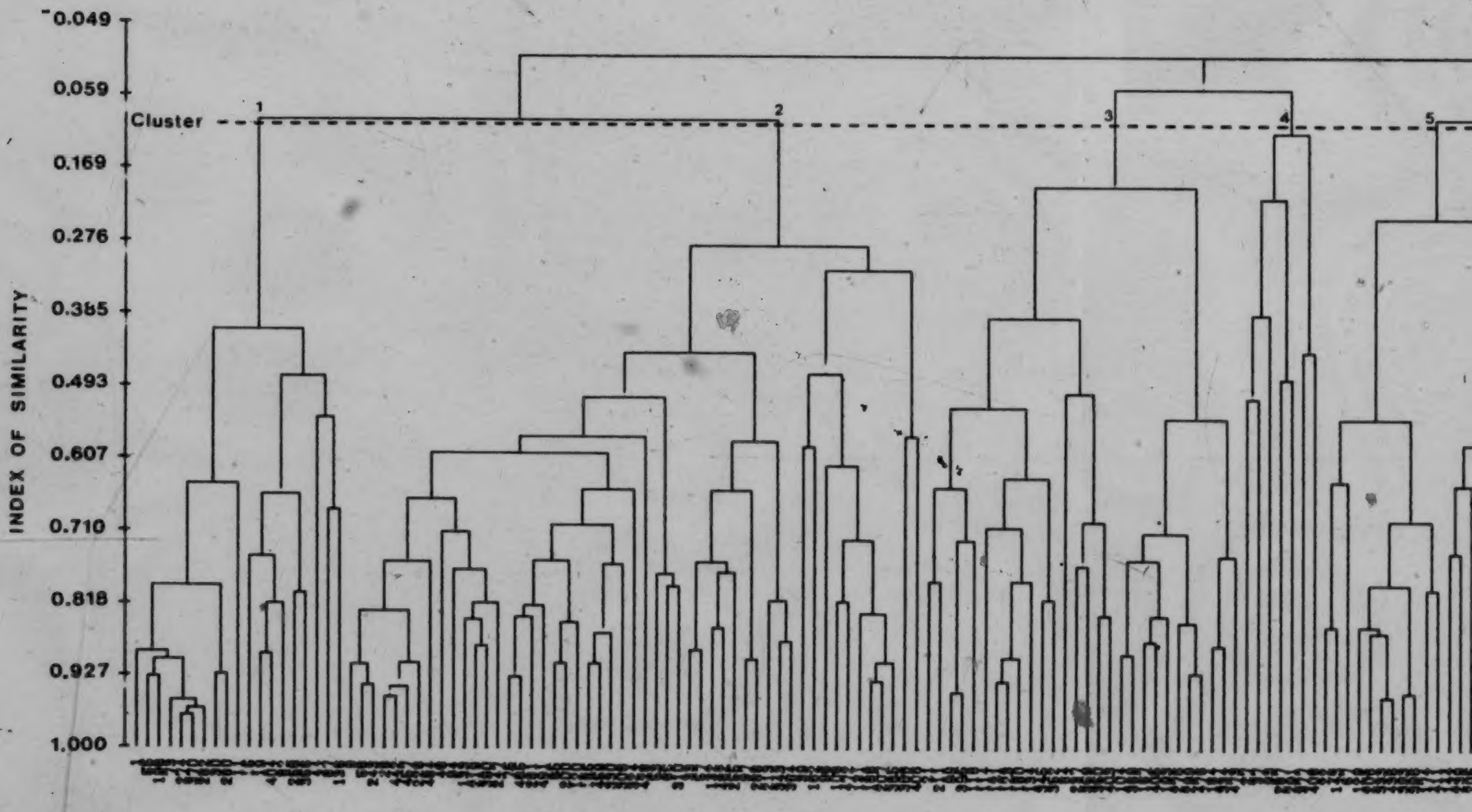
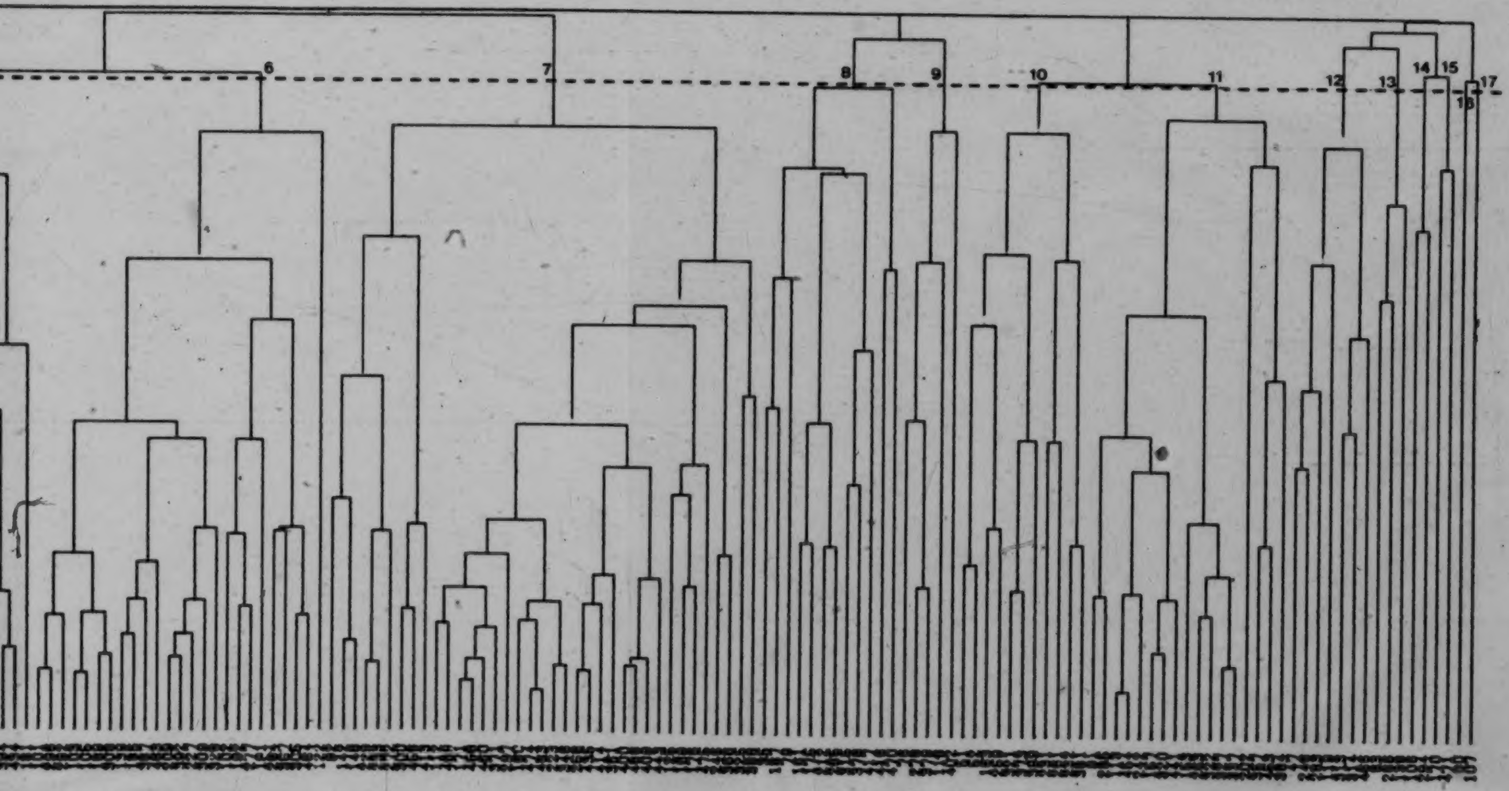


Figure 8. Dendrogram of Forest Sites

COMPLETE-LINKAGE CLUSTER ANALYSIS

MACMILLAN PASS/SHELDON LAKE AREA, YUKON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Cluster 8 (IS=.107) consists of 12, predominantly mesic, sites where ground cover is dominated by *Polytrichum juniperinum*. The LS stratum is dominated by *Ledum palustre*, and the MS stratum by *Betula glandulosa*.

Cluster 9 is a loose cluster (IS=.169) of 5 sites characterized by a very high cover of *Polytrichum juniperinum*. There are no other diagnostic species.

Cluster 12 (IS=.186) consists of 7 southerly-facing mesic sites characterized by *Salix* spp. in the TS and MS strata. The ground cover is dominated by forbs.

Cluster 13 (SI=.266) consists of 3 steeply sloping sites characterized by *Festuca altaica*. The MS stratum is dominated by *Betula glandulosa* and *Salix* spp..

Clusters 15 - 17 are small clusters of early to mid-successional stands. Cluster 15 consists of two loosely associated (IS=.215) south-facing, steeply sloping sites. The TT stratum is dominated by *Picea glauca*. *Populus* spp. are also present. The ground cover is dominated by forbs.

Cluster 16 consists of a primary-successional, alluvial site on a tributary of the Hess River. The MS and LS strata are dominated by a low cover of *Populus balsamifera* and *Salix* spp.. Ground cover is dominated by *Stereocaulon* sp.

Cluster 17 consists of one early succesional alluvial site on the Hess River. Ground cover is dominated by *Dicranum* sp.. The TS and MS strata are dominated by a dense cover of *Populus balsamifera* and *Salix* spp.

5.3 Community Types

5.3.1 Abies lasiocarpa/Hylocomium splendens CT

Cl# 1, IS=.410, n=19: 1,11,15,19,30,44,55,73,82,87, 136,198,258,274,280,282

ABLA/HYSP is a stable CT found predominantly on mesic, northerly-facing, gentle to steep (10-40%) mid-slope sites between 1160 and 1525 m. The most common soils are moderately-well to well-drained, moderately pervious Brunisols, represented by Orthic Dystric, Orthic Eutric, and Eluviated Dystric Brunisols. Podzols, Regosols, and Cryosols are also found. Soils are very strongly acidic to strongly acidic; pH of the rooting zone ranges from 3.3 to 4.6. Soil texture ranges from clay loam to loamy sand. The dominant terrain types are coarse-textured colluvial blankets and veneers, and morainal blankets.

Abies lasiocarpa is the dominant tree species with between 30 and 80% cover. Near treeline, the trees assume a krummholz growth-form, tall trees (TT) are absent or rare, and the majority of trees occur in the medium (MS) and low shrub (LS) height-classes. At lower elevations TT account for approximately half of the total cover, regeneration in the MS class accounts for the remainder. *Betula glandulosa*, and/or *Salix* spp. occasionally occur. *Empetrum nigrum* occurs frequently, with *Vaccinium vitis-idaea* occurring less often. In the high-elevation sites, *Cassiope tetragona* occurs in the openings between trees. *Hylocomium splendens* dominates the ground with a cover of 25 to 90%. Fruticose lichens, predominantly *Cladina stellaris, Cetraria cucullata,* and *Cladonia* spp. occur commonly, usually with a low cover. *Nephroma arcticum*, a foliose lichen, occurs with a high constancy, and often with a high cover value. *Peltigera aphthosa* occurs occasionally with a low cover value.

Abies lasiocarpa can attain heights of 9 metres, with BA ranging from 4-55 m^2/ha. Tree ages are generally less than 140 years.

Plate 12. ABLA/HYSP CT. Site 30. Keele Peak. (130° 30′ W, 63° 23′ N). Elev. - 1550 m. Krummholz subalpine fir found on moderately sloping NW-facing site. The ground cover is dominated by *Hylocomium splendens* (75%), *Nephroma arcticum* (15%) and *Empetrum nigrum* (10%). Date sampled - June 19, 1981.

Plate 13. ABLA/HYSP CT. Site 73. SW of Emerald Lake. (63° 27′ 50′ N, 131° 23′ 50″ W) Elevation - 1470 m. Occurring on a moderately sloping, S-facing site. Soil is an Orthic Regosol formed on colluvium. Trees were rooting between rock fissures. Date sampled - June 27, 1981.

5.3.2 Picea glauca/Hylocomium splendens CT

Cl# 2, IS=.510, n=30:9,28,48,53,66,75,85,94,120,133,185,
200,219,228,243,247,281, 306,310,324,330,390,428,442, 457,459,484,485,491

The PIGL/HYSP community is found predominantly on subhygric to mesic, level to gently sloping, southerly-facing sites, on valley floors or lower slopes. Elevations range from 650 to 1300 m, mostly below ABLA/HYSP sites. The most common soils are imperfectly to moderately-well drained, slowly to moderately pervious Regostatic Cryosols. Brunisolic Static Cryosols, Gleysolic Static Cryosols, Ortho Static Cryosols and Terric Mesic Organic Cryosols are also found. The next most prevalent groups are Gleysols, represented mainly by Rego-Gleysols. Frost was present in 18 of 28 soil profiles at depths of 8 to 50 cm. Water occurred in six profiles at depths of 20 to 60 cm. The dominant parent material is alluvial plains, veneers and blankets, followed by morainal blankets. Soil pH's in the rooting zone are higher than in other community types, ranging from very strongly to slightly acidic (4.6-6.1)

This community type can be separated into two major subtypes (ST): lower elevation sites found on alluvium along the major rivers (ST 2.1); and higher elevation, moderately sloping sites occurring on morainal material (ST 2.2).

ST 2.1 sites are characterized by pure stands of white spruce, though rarely black spruce may also occur. Late successional sites may also have *Populus* spp. present.

ST 2.2 sites are normally dominated by white spruce, though one or possibly both black spruce or subalpine fir may be present. The white spruce typically assumes a black spruce-like growth form.

The understory of both subtypes is characteristically species rich. *Salix* sp. is almost always present, often with a high cover value. *Betula glandulosa* and *Alnus crispa* occur less commonly. Low shrubs which are often present are *Vaccinium uliginosum, Rosa acicularis, Ledum palustre,* and *Potentilla fruticosa. Shepherdia canadensis* and *Ribes triste* often occur in association with *Populus* sp.. Ground shrubs often present are *Vaccinium vitis-idaea, Empetrum nigrum, Rubus chamaemorus, Cornus canadensis, Arctostaphylos rubra,* and *Linnaea borealis*. Numerous forbs are present, the most common being *Mertensia paniculata, Lupinus arcticus, Polemonium acutifolium, Pyrola secunda,* and *Senecio lugens.* Subtype 2.1 sites often have a higher proportion of grasses and horsetails present. In both subtypes, *Hylocomium splendens* dominates the ground with over 55% cover. The foliose lichen, *Peltigera aphthosa* is usually present, with *Nephroma arcticum* tending to replace it on higher elevation sites. Cladinae and Cladoniae lichens may be present, but usually in trace amounts.

5.3.3 Picea mariana/Hylocomium splendens CT

CI #2, IS=.309, n=21:33,39,57,97,98,108,131,132,162,188,207, 213,255,288, 343,364,366,385,406,472,482

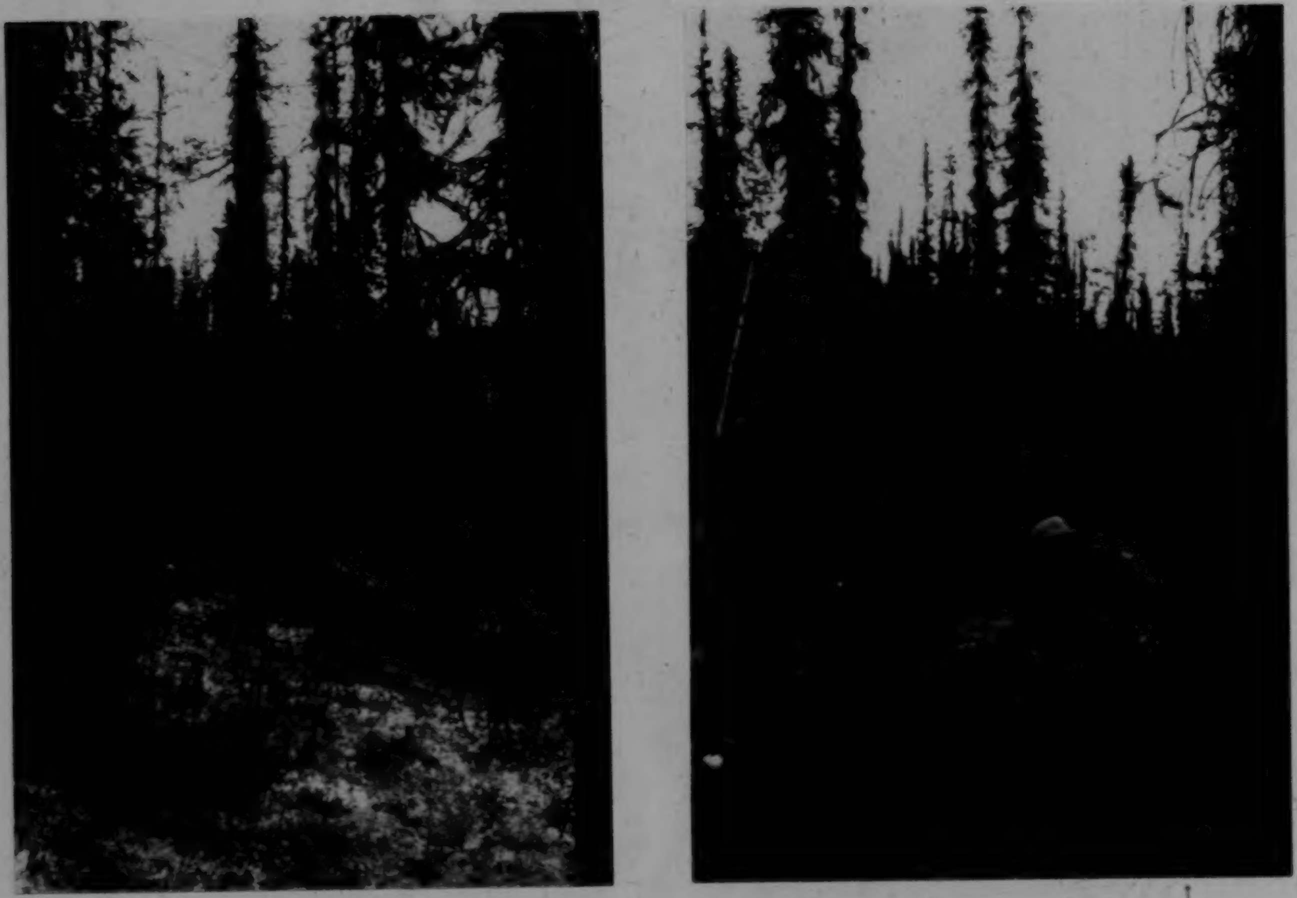
The PIMA/HYSP CT can be separated into two phases (PH): Phase 3.1, PIMA/HYSP, and Phase 3.2, PIMA/HYSP-SPH. Both PH's occur on subhygric to mesic sites over a wide elevational range (610-1220m). Soils are predominantly poorly to imperfectly drained, slowly to moderately pervious Cryosols and Gleysols, with Regostatic Cryosols being most common, followed by Rego Gleysols. The pH of the rooting zone ranges from extremely to moderately acidic (4.5-5.9). Frost was present in 10 of 18 soil profiles at depths of 13 to 52 cm. Water was present in 6 of the profiles at depths of 1 to 85 cm. Morainal blankets and rolling morainal material are the dominant parent materials. While both phases occur predominantly on valley floors and lower slopes, the PIMA/HYSP phase occurs on level to strongly sloping sites, while the PIMA/HYSP-SPH phase occurs on level to moderately sloping sites.

Both phases are characterized by dominance of *Picea mariana* in the tree stratum, and of *Hylocomium splendens* in the ground cover. In the PIMA/HYSP phase the cover of *H. splendens* ranges from 45-90%, and *Sphagnum* from 0-20%. In the PIMA/HYSP-SPH phase the range of *Hylocomium splendens* is only 30-50%, while that of*Sphagnum* is 10-50%. *Salix* sp. is always present in both phases, often with a high cover value. *Vaccinium uliginosum* is often present, sometimes with high cover (0-20%). *Cladina stellaris* is almost always present (<1 to 20%). *Nephroma arcticum* is the common foliose lichen.

Tree ages in both phases range from 50 to 205 years. Productivity is greater in PH 3.1, based on tree height and basal area. One tree in a PH 3.2 stand was 3.6 m tall at 205 years of age. Phase 3.2 may be a later successional stage of Phase 3.1.

Plate 14. PIGL / HYSP - Alluvial Phase. Site 247, located on an alluvial plain, South Macmillan River (62° 59' 00" N, 131° 02' 40" W). Elevation - 850 m. *Hylocomium splendens* (75%) and *Ptilium crista-castrensi* (10%) are the common byroids. *Arctagrostis latifolia* (15%) and *Equisetum pratense* (20%) dominate the herb stratum. The tallest tree was 20 m and 125 years old. Date sampled - July 11, 1981.

Plate 15. PIGL / HYSP - Morainal Phase. Site 28, SW of Keele Peak. Elevation - 1280 m. Occurring on a gentle S-facing lower slope. Soil is a OHFP formed on a morainal blanket. Frost was present at 8 cm. *Picea glauca* and *Abies lasiocarpa* are co-dominants in the TT stratum, but *A. lasiocarpa* is dominant in the LT and MS strata. Date sampled - June 24, 1981.



Plates 16 & 17. PIMA/HYSP, Site 97 & 98, NW of Niddery Lake in the Hess River Valley. Phase 3.1, on the right occurs at 1100 m on a moderate, SW-facing slope. Phase 3.2, PIMA/HYSP-SPH, is located further down the same slope. Elevation - 890 m. Soils of both sites are R.SC. Date sampled - July 1, 1981.

5.3.4 Conifer/Pleurozium schreberi CT

Cl# 7, IS=.169, n=36:92,112,125,142,148,160,169,171,176,223,229,246, 268, 272,297,300,325,346,361,368,371,388,400,409,413,414,435,443, 456,458, 460,474,475,483,488,489

This community is characterized chiefly by the high cover value of *Pleurozium schreberi*. Three subtypes are recognized, based on the major tree species present: ST 4.1, *Picea mariana*; ST 4.2, *P. glauca* and ST 4.3, *Abies lasiocarpa*. *Betula glandulosa* and *Vaccinium uliginosum* are the predominant erect shrubs, with *Empetrum nigrum* and *Vaccinium vitis-idaea* again being the common prostrate shrubs. Cladinae lichens are common with *Cladina stellaris* occurring most often and with the highest cover value. *Nephroma arcticum* and *Peltigera aphthosa* are common foliose lichens.

This predominantly mesic community type occurs over a wide elevational range (660-1430m), occupying a position in the landscape from valley floors to mid-slopes. Slopes are generally less than 20%. Soils are typically moderately pervious, imperfectly to well-drained Brunisols and Regostatic Cryosols. The ph of the rooting zone ranges from extremely acidic to moderately acidic (3.3-5.9). Parent materials are typically morainal or alluvial.

Picea glauca is the dominant tree species found on the low-elevation glacio-fluvial and alluvial sites (ST 4.1), where soils are slightly less acidic than in ST's 4.2 and 4.3. ST 4.1 is very similar to the PIGL/HYSP community except that *Hylocomium splendens* is replaced by *Pleurozium schreberi*. *Picea mariana* may be present. As with the PIGL/HYSP community, forb species are numerous, some of the more common being *Pyrola secunda, Lupinus arcticus, Mertensia paniculata, and Petasites frigidus*. Shrubs that occur in this subtype and in the other *Picea glauca* communities, but rarely elsewhere, are *Rosa acicularis, Ribes triste*, and *Shepherdia canadensis*. *Salix* sp. is more common in this ST than in the two others. Grasses which occur commonly are *Arctagrostis latifolia, Festuca altaica*, and *Calamagrostis canadensis*.

Abies lasiocarpa (ST 4.2) is common at higher elevations on steeper slopes, occurring on moderately-well drained Brunisols, with morainal parent material. It is normally associated with an increase in *Hylocomium splendens*. This subtype differs from the ABLA/PLSC CT in that it has a lower cover of *Abies lasiocarpa* (12-33% cf. 24-70%); *Ledum palustre* is common cf. absent or rare; and *Dicranum* sp. is rare or absent cf.

common.

Picea mariana is the most common tree in ST 4.3, which is found predominantly on imperfectly drained Cryosolic soils. It may also be found on moderately well-drained Brunisols and Regosols. Parent material is usually morainal. In addition to being dominated by *Picea mariana*, this ST is separated from the other two by the occurrence of *Sphagnum* sp. and *Rubus chamaemorus*, both of which are absent from the other subtypes.

5.3.5 Abies lasiocarpa/Pleurozium schreberi CT

Cl# 11, IS=.149, n=17:91,113,153,157,202,242,263,285,320,322, 327,337,357, 384,441,453,454

The ABIA/PLSC CT is very similar to the ABLA/HYSP CT except that *Pleurozium schreberi* replaces *Hylocomium splendens*. It is found predominantly on high elevation (1100-1500 m) mesic slopes, occupying lower to upper slope positions with a variety of aspects. Soils are predominantly moderately-well to well-drained Eluviated Dystric Brunisols, though it is also found on Podzols, Gleysols, and Cryosols. The pH of the rooting zone is extremely acidic (3.4-4.5). The parent material is either morainal, colluvial or alluvial veneers and blankets.

Abies lasiocarpa is the only tree species occurring in this community type. It typically has between 25 and 70 percent cover, with the higher cover values again due to the low-stature krummholz near the upper treeline. The ground cover is normally dominated by *Pleurozium schreberi*, though occasionaly *Dicranum* sp. is dominant, and rarely *Hypnum* sp., or *Ptilidium* sp.. *Cladina stellaris* or *Stereocaulon* sp. may be locally dominant in patchy openings.

The dominant trees in the TT stratum range in height from 6 to 19 metres. The BA range is 10-60 m^3/ha. Tree ages range from 120 to 260 years.

5.3.6 *Picea mariana*/*Pleurozium schreberi-Sphagnum* CT

CI# 6, IS=.178, n=25: 101, 102, 103, 105, 122, 139, 186, 189, 191, 192, 209, 227, 264, 277, 292, 296, 305, 308, 309, 328, 367, 387, 392, 463, 464

PIMA/PLSC-SPH is a subhygric CT found predominantly on level valley floors or gentle north-facing lower slopes between 790 and 1440 m. The most common soils are slowly pervious, imperfectly drained Cryosols represented mainly by Regosolic Static Cryosols. The pH of the rooting zone ranges from extremely to very strongly acidic (3.5-4.9); the soil texture from silty clay loam to sandy loam. Frost was present in 14 of 19 profiles at depths of 7-39 cm. Water was present in 5 profiles at depths of 18-44 cm. Morainal blankets and veneers are the common parent material though organic, lacustrine and colluvial materials are also found.

Picea mariana is normally the dominant tree within this type. However, at higher elevations, *Abies lasiocarpa* may occasionally be a co-dominant, and rarely the major tree species; it often has a high cover value in the MS stratum, suggesting that *A. lasiocarpa* may be the climax dominant on these sites. Tree ages ranged from 57 to 205 years, with heights ranging from 5.5 to 12 m.

Ledum palustre is the dominant erect shrub, followed by *Betula glandulosa, Vaccinium uliginosum*, and *Salix* spp.. As in the majority of the other community types, *Vaccinium vitis-idaea*, and *Empetrum nigrum* are the most common prostrate shrubs. *Oxycoccus microcarpus* is also common. Common forbs are *Rubus chamaemorus* and *Petasites frigidus*. *Pleurozium schreberi* is the dominant moss, occurring on all sites, with cover values ranging from 20-65%, with a mean of 41%. *Sphagnum* also occurs on every site, with cover values ranging from 16 to 65%, and a mean of 33%. *Hylocomiun splendens, Dicranum* sp., and *Polytrichum juniperinum* are also present. Cladinae lichens are normally present; *Cladina stellaris* is the most common, with cover values ranging from <1 - 40%, followed by *C. rangiferina* and *C. mitis*.

Plate 18. PIMA/PLSC-SPH. Site 103, Mt. Sheldon, (63° 48′ 30″ N, 130° 60′ 00″ W). Elevation - 950 m. Soil was a R.SC. with frost at 20 cm. Date sampled - July 4, 1981. *Pleurozium schreberi* (65% cover) and *Sphagnum* sp. (25%) were the dominant bryophytes, *Rubus chamaemourus* was the common forb (15% cover).

5.3.7 Picea mariana/Sphagnum-Cladina stellaris CT

Cl# 5, IS=.241, n=18,22,67,129,143,144,174,181,205,206,210, 239,333, 393,394,396,411,434,436

The PIMA/SPH-CLST CT is a subhygric community found predominantly on level valley floors or gentle northerly-facing lower slopes between 820 and 1220 m. The most common soils are slowly pervious, poorly to imperfectly drained Cryosols, represented by Gleyed Static, Fibric Organic, and Regosolic Static Cryosols. Soil pH in the rooting zone varies from very strongly to strongly acidic (4.4-5.5); textures include silty clay loams, clay loams, and silty loams. Frost was present in all profiles at depths of 6-44 cm, water was present in 8 of 13 profiles at depths of 6-44 cm. Parent materials are predominantly morainal and organic blankets and veneers.

Picea mariana is the dominant tree species (5-30% cover), though both *Abies lasiocarpa* and *Picea glauca* may be present. Trees in this community are somewhat younger than those in the other CT's, with ages ranging from 46 to 110 years. Heights range from 4.5 to 10 m.

Species composition, in terms of erect and prostrate shrubs and forbs, is similar to that of PIMA/PLSC-SPH. The major difference between these two CT's is the relative percent cover of *Pleurozium schreberi*, *Sphagnum*, and *Cladina stellaris*. In PIMA/SPH-CLST the cover range of *Pleurozium schreberi* is <1-30%, with a mean of 13%, in contrast to 20-60%, with a mean of 41% in PIMA/PLSC-SPH. *Sphagnum* has 20-80% cover, with a mean of 48% in PIMA/SPH-CLST, while in PIMA/PLSC-SPH it's cover is 16-25%, with a mean of 33%. In PIMA/SPH-CLST *Cladina stellaris* cover ranges from <1-60%, with a mean of 29%, while in PIMA/PLSC-SPH it ranges from <1 to 40%, with a mean of 12%.

Plate 19. PIMA / SPH-CLST CT. Site 393, SE of Field Lake, (62° 38′ 20″ N, 131° 09′ 00″ W). Occurring on a valley floor (elev. - 910 m.), soil is a T.FOC, frost was present at 9 cm. Note the *Cladina stellaris* growing on top of the *Sphagnum*. Date sampled - August 5, 1981.

5.3.8 Abies lasiocarpa/Empetrum nigrum/Polytrichum juniperinum CT

CI# 10, IS=.200, n=9:51,52,163,259,321,373,399,261,381

ABLA/EMNI/POJU community is a stable community occurring at high elevations (1125-1800m), predominantly on well-drained moderately pervious Brunisolic soils. The pH of the rooting zone ranges from extremely to very strongly acidic (3.6-4.9). Sites are characteristically mesic to subxeric and occupy positions in the landscape from lower slopes to apices. The dominant terrain types are coarse-textured morainal and colluvial blankets and veneers, though this community also occurs on glacio-fluvial and bedrock parent materials.

Abies lasiocarpa is the dominant tree species (15-50% cover). The highest cover values are found in dense krummholz fir sites near treeline. Ground cover is dominated by bryophytes, mostly *Polytrichum juniperinum*, though *Dicranum* sp. and *Pleurozium schreberi* are also common. On the more open, well-drained, lower-elevation sites, where krummholz is rare or absent, *Cladina stellaris* is common. *Empetrum nigrum* is always present, obtaining its highest cover values on the more open sites where *Betula glandulosa* also has a tendency to occur. Grasses and forbs are notably absent from this community type.

5.3.9 Abies lasiocarpa/Empetrum nigrum CT

CI# 4, IS=.190, n=4:27,37,93,408

The ABLA/EMNI community type is found predominantly on steeply sloping, south-facing, mesic to submesic sites. Soils are typically moderately-well and well-drained, moderately pervious Eluviated Dystric Brunisols. Orthic Humo-Ferric Podzols and Orthic Eutric Brunisols also occur. Soil pH of the rooting zone ranges from extremely acidic to strongly acidic (3.8-5.2). Parent materials are predominantly morainal veneers, however; colluvial and glacio-fluvial materials are also found. Elevation ranges from 1220 to 1560 m.

This community is characterized by having *Empetrum nigrum* present with a high cover value. Either *Cladina mitis, C. stellaris, or Stereocaulon* sp. are also abundant. *Betula glandulosa* and *Vaccinium uliginosum* are commonly occurring erect shrubs. *Lycopodium* spp. are common. *Polytrichum juniperinum* is present on all sites;

feathermosses may occur. *Abies lasiocarpa* is the dominant tree species, occurring on the higher elevation, south-facing sites. It may reach heights of 12 m.

A major floristic difference between this community and ABLA/EMNI/POJU is the cover and growth form of *Abies lasiocarpa*. ABLA/EMNI is a more open community with *A. lasiocarpa* having a cover value of 10-30%, with a mean of 16%, while in ABLA/EMNI/POJU the range is from 16-52%, with a mean of 30%. In the latter CT trees tend to have a krummholz growth-form.

5.3.10 Abies lasiocarpa-Picea mariana/Cladina stellaris CT

CI# 3, IS=.195, n=28:21,84,99,104,114,116,121,123,134,167,
180,184,193,211,237, 267,299,334,345,350,352,359,369,395,403, 405,473,476

The ABLA-PIMA/CLST community type is found on mesic to submesic, level to gently sloping sites between 850 and 1500 m. The most common soils are well-drained, moderately pervious Eluviated Dystric Brunisols and Orthic Humo-Ferric Podzols. Soils in the rooting zone are extremely to strongly acidic (3.6-5.2); texture ranges from silty loam to sandy loam. Parent materials are predominantly glacio-fluvial and morainal blankets and veneers.

Two phases occur within this community type: PH 10.1, ABLA-PIMA/CLST, and PH 10.2, ABLA-PIMA/PLSC-CLST. PH 10.1 is very similar to, and is perhaps a later succesional stage of the BEGL/CLST CT found in the non-forested zone. Any of the three conifers may be present, with a combined cover value of 10-30%. *Betula glandulosa, Vaccinium uliginosum*, and *Ledum palustre* are the common erect shrubs. *Empetrum nigrum* and *Vaccinium vitis-idaea* are common prostrate shrubs, with *Cassiope tetragona* present at higher elevations. The ground cover is dominated by *Cladina stellaris* (30-80%), though *C. rangiferina, C. mitis*, and *Cetraria nivalis* occur commonly, but with a lower cover value. *Hylocomium splendens, Pleurozium schreberi, Dicranum* sp. and *Polytrichum juniperinum* often occur but always with individual species cover values of <30%. Feathermosses reach their highest cover values on sites with a relatively high tree cover, while *Polytrichum juniperinum* and *Dicranum* sp. occur on the more open sites. Forbs, except for rare individuals of *Cornus canadensis* or *Rubus chamaemorus*, are absent.

PH 10.2 is similar in most respects to the PH 10.1 except that the mean cover of *C. stellaris* is lower, and *Pleurozium schreberi* has a cover ranging from 40 to 70%. Total tree cover and basal area are higher in PH 10.2, which is possibly a later successional stage of the PH 10.1. However, tree ages are similar in both phases, ranging from 103-204 years, suggesting that the 2nd phase occur on more productive and/or better stocked sites.

Plates 20 & 21. ABLA-PIMA / CLST CT, Phase 10.1, Site 99, Hess River Valley, (63° 20' 10" N, 131° 35' 00" W). Elevation - 880 m. Open black spruce / lichen woodland. Total tree cover is ca. 13%. The soil is a well-drained O.HFP formed on a glacio-fluvial terrace. Notice the volcanic ash below a very thin Ah horizon. Date sampled - July 1, 1981.

Table 9. Site data for four stands in each of the three HYSP CT's recognized in the Macmillan Pass Study area. Definitions of the abbreviations are given in Appendix III , Site forms and Surficial Geology forms. The last two letters of the terrain type refer to the parent material, i.e. M.B is morainal blanket, the first letters are material texture. Plant species cover data are in Table 10. A '*' indicates that a site photo is included in the text.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth to Water	Depth to Frost	Soil Subgroup	Terrain Type
ABLA/HYSP CT											
1.	1190.	E	10.	MS	S	SH	I	-.	7.	GLSC	P -L.B
30.	1550.	NW	25.	MS	M	SM	W	-.	-.		GS-C.B
73.*	1470.	S	25.	MS	M	M	MW	-.	-.	OR	R$-R.M
356.	1000.	W	20.	MS	M	M	W	-.	-.	EDYB	GS-M.B
PIGL/HYSP CT											
28.	1280.	S	25.	LS	M	M	MW	-.	8.	OHFP	$C-M.B
85.	1115.	SW	3.	LS	M	SH	W	20.	40.	TMOC	-O.V
247.*	840.	L	0.	VF	M	M		-.	-.		
459.	1060.	SE	5.	LS	S	M	I	-.	45.	RSC	PS-A.V
PIMA/HYSP CT											
33.	1055.	NW	25.	LS	S	H	P	-.	41.	RSC	F -L.M
97.*	1100.	SW	30.	MS	S	M	VP	-.	23.	RSC	
98.*	890.	SW	6.	LS	S	SH	I	-.	20.	RSC	PC-M.B
472.	870.	L	0.	VF	M	SH	W	-.	45.	TMOC	E -O.B

Table 10. Estimated % cover of plant species in four sites in each of three HYSP communities recognized in the forest zone of the Macmillan Pass/Sheldon Lake region. A '+' indicates occurrence in trace amounts. Site data are in Table 9.

	Hylocomium splendens Communities Types and Site Numbers											
	Abla/Hysp				Pigl/Hysp				Pima/Hysp			
Species	1	30	73	356	28	85	247	459	33	97	98	472
Trees												
Abies lasiocarpa	34	60	35	28	--	--	--	--	--	--	--	--
Picea glauca	--	--	--	--	10	15	25	27	--	--	1	--
Picea mariana	12	--	--	--	--	10	--	--	14	17	12	25
Betula occidentalis	--	--	--	--	--	--	--	13	--	--	--	--
Erect Shrubs												
Betula glandulosa	7	--	+	3	5	--	--	+	2	10	--	18
Salix sp.	--	--	6	--	2	20	5	13	16	--	12	4
Vaccinium uliginosum	3	--	3	--	7	1	--	4	30	+	9	15
Ribes triste	--	--	5	1	--	+	--	8	--	--	--	--
Rosa acicularis	--	--	+	--	+	+	--	3	--	--	2	--
Spiraea beauverdiana	--	--	--	+	--	--	--	--	--	--	--	--
Ledum palustre	--	--	--	--	1	3	--	1	11	5	17	10
Alnus crispa	--	--	--	--	--	--	--	--	--	3	5	--
Potentilla fruticosa	--	--	--	--	--	--	--	--	1	--	--	5
Prostrate Shrubs												
Empetrum nigrum	+	10	1	--	+	3	--	+	2	1	1	1
Vaccinium vitis-idaea	+	--	--	2	+	5	--	1	1	5	15	1
Oxycoccus microcarpus	--	--	--	--	--	--	--	--	+	+	--	+
Linnaea borealis	--	--	+	--	+	--	1	--	--	--	--	--
Cassiope tetragona	--	3	--	2	--	--	--	--	--	--	--	--
Arctostaphylos rubra	--	--	--	--	--	3	--	--	3	--	5	2
Salix reticulata	--	--	--	--	--	--	--	--	10	--	--	+
Forbs												
Artemisia arcticum	--	--	--	+	--	--	--	--	--	--	--	--
Cornus canadensis	--	--	3	--	2	--	--	10	--	--	--	--
Epilobium angustifolium	--	--	1	--	--	+	--	--	--	--	--	--
Mertensia paniculata	--	--	1	--	--	--	1	--	+	--	+	--
Petasites frigidus	--	--	--	1	--	--	3	+	+	--	--	--
Polemonium acutiflorum	--	--	--	+	--	--	+	--	--	--	--	--
Pyrola asarifolia	--	--	+	--	--	--	--	--	--	--	--	--
Pyrola secunda	--	--	--	2	--	+	+	--	--	--	--	--

Table 10 continued.

Species	Abla/Hysp				Pigl/Hysp				Pima/Hysp			
	1	30	73	356	28	85	247	459	33	97	98	472
Rubus arcticus	--	--	--	2	--	--	2	+	--	3	5	--
Rubus chamaemourus	+	--	--	+	--	+	--	1	--	--	--	1
Moneses uniflora	--	--	--	--	--	--	1	--	--	--	--	--
Pedicularis labradorica	--	--	--	--	+	--	--	--	--	--	+	--
Graminoids												
Festuca altaica	--	--	+	--	+	--	--	--	--	--	--	+
Poa lanata	--	--	--	1	--	--	--	--	--	--	--	--
Calamagrostis canadensis	--	--	--	--	--	--	--	--	+	--	5	--
Arctagrostis latifolia	--	--	--	--	--	--	15	--	--	--	--	--
Pteridophytes												
Equisetum arvense	--	--	--	--	--	--	--	3	--	--	3	--
Lycopodium annotinum	--	--	2	--	--	--	--	+	--	--	--	--
Lycopodium selago	--	+	--	--	--	--	--	--	--	--	--	--
Equisetum pratense	--	--	--	--	--	--	20	--	--	--	--	--
Equisetum scirpoides	--	--	--	--	--	2	--	--	--	--	6	--
Equisetum sylvaticum	--	--	--	--	--	--	--	--	5	2	--	--
Bryophytes												
Aulacomnium palustre	+	5	--	--	--	2	--	--	5	2	18	1
Dicranum sp.	--	--	5	5	--	--	1	+	--	--	1	5
Hylocomium splendens	75	75	85	50	85	60	75	80	70	55	40	50
Pleurozium schreberi	--	--	--	10	--	+	--	--	10	25	--	10
Polytrichum juniperinum	--	+	--	10	--	--	1	5	5	--	--	3
Leafy Liverworts	--	--	--	5	--	--	+	--	+	--	--	--
Mnium sp.	--	--	--	--	--	+	--	--	+	--	--	--
Ptilium crista-castrensi	--	--	--	--	--	--	10	--	--	--	--	--
Sphagnum sp.	--	--	--	--	5	--	--	--	2	3	15	25
Tomenthypnum nitens	--	--	--	--	--	--	--	--	--	1	3	10
Lichens												
Cetraria cucullata	--	3	--	2	--	--	--	--	--	--	--	--
Cladina stellaris	7	5	5	+	7	3	--	--	1	13	3	--
Cladina rangiferina	1	+	3	--	+	+	--	--	--	2	--	1
Cladina mitis	1	+	3	--	+	+	--	--	3	--	--	5
Cladonia sp.	+	+	--	5	+	+	+	+	--	+	+	+
Dactylina arctica	--	+	--	2	--	--	--	--	--	--	--	--
Nephroma arcticum	12	15	5	25	5	5	--	+	--	2	1	--
Peltigera aphthosa	+	--	5	3	3	1	2	1	--	2	--	--

Table 11. Site data for four stands in each of four CT's recognized in the forest zone of the Macmillan Pass study area. Plant species cover data are in Table 12. A '*' indicates that a site photo is included in the text.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth Water	Depth Frost	Soil Subgroup	Terrain Type
ABLA/PLSC CT											
168.	1585.	S	50.	US	M	M	MW	-.	-.	ODYB	R -C.V
346.	1150.	N	20.	LS	M	M	I	-.	50.	RTC	GB-M.B
475.	880.	S	20.	LS	M	M	W	-.	-.	ODYB	GS-M.B
488.	1255.	SE	22.	MS	M	M	MW	-.	-.	EDYB	$ -M.
CONIFER/PLSC CT											
91.	1400.	S	17.	MS	M	SH	P	24.	24.	RSC	P -A.B
153.	1415.	W	5.	MS	M	M	MW	-.	-.	OHFP	PS-A.B
247.	840.	L	0.	VF	M	M	MI	-.	-.		
320.	1340.	N	15.	MS	R	SM	W	-.	-.	EDYB	P$-M.V
PIMA/PLSC-SPH CT											
103.*	960.	NW	4.	LS	S	SH	MW	-.	20.	RSC	-M.M
139.	1183.	SE	10.	VF	M	SH	I	-.	1.	RSC	.
292.	990.	L	0.	VF	S	SH	I	-.	-.		
376.	1490.	S	30.	US	M	M	W	-.	-.	OR	G$-C.V
PIMA/SPH-CLST CT											
22.	1185.	N	3.	VF	M	SH	P	6.	10.	RG	P$-A.F
174.	1065.	NW	0.	LS	M	SH	I	-.	-.		
393.*	920.	NE	4.	VF	R	SH	I	-.	9.	TFOC	E -O.B
434.	1005.	N	0.	VF	S	SH	I	-.	1.		

Table 12. Estimated % cover of plant species in four sites in each of four *Pleurozium schreberi* and/or *Sphagnum*-dominated community types recognized in the Macmillan Pass/Sheldon Lake region. A '+' indicates occurrence in trace amounts, a '--' indicates species absence. Site data are presented in Table 11.

	Pleurozium & Sphagnum-dominated community types and site numbers															
	Abla/Plsc				Conifer/Plsc				Pima/Plsc-Sph				Pima/Sph-Clst			
Species	91	153	242	320	488	346	268	475	103	139	292	367	22	174	393	434
Trees																
Abies lasiocarpa	50	37	40	70	31	18	--	--	2	10	--	--	+	--	--	--
Picea glauca	--	--	--	--	--	--	25	--	--	--	--	--	--	--	--	--
Picea mariana	--	--	--	--	1	12	--	29	22	21	18	14	11	23	21	13
Erect Shrubs																
Salix sp.	--	--	13	--	--	--	3	4	1	5	--	--	5	--	--	--
Ribes triste	--	--	2	--	--	--	10	--	--	--	--	--	--	--	--	--
Rosa acicularis	--	--	+	--	--	--	5	--	--	--	--	--	--	--	--	--
Betula glandulosa	+	3	--	10	2	7	--	9	3	8	8	5	11	6	1	1
Vaccinium uliginosum	--	--	--	+	+	5	2	5	2	3	5	+	2	2	3	3
Ledum palustre	+	--	--	--	1	10	--	7	10	5	20	15	2	10	10	20
Prostrate shrubs																
Phyllodoce empetriformis	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cassiope tetragona	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Empetrum nigrum	--	5	--	--	5	1	+	--	2	5	+	15	+	--	--	2
Vaccinium vitis-idaea	--	+	+	+	+	1	1	8	2	1	2	+	+	2	2	+
Oxycoccus microcarpus	--	--	--	--	--	+	--	--	+	--	+	+	+	+	+	+
Juniperus communis	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--
Forbs																
Artemisia arcticum	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
Mertensia paniculata	--	--	10	--	--	--	--	--	--	--	--	--	--	--	--	--
Aconitum delphinifolium	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--
Lupinus arcticus	--	--	1	--	--	--	--	+	--	--	--	--	--	--	--	--
Epilobium angustifolium	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--
Senecio atropurpureus	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrola asarifolia	--	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--
Pyrola secunda	--	--	--	--	--	--	+	--	--	--	--	--	--	--	--	--
Rubus arcticus	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rubus chamaemourus	--	--	--	--	--	10	--	--	15	10	3	15	+	30	2	5
Petasites frigidus	--	--	--	--	--	--	--	--	--	2	--	--	+	--	--	--
Cornus canadensis	2	--	15	--	2	--	--	--	--	--	--	--	--	--	--	--
Geocaulon lividum	--	--	--	--	--	--	--	+	--	--	--	--	--	--	--	--

Table 12 continued.

	Pleurozium & Sphagnum-dominated community types and site numbers															
	Abla/Plsc				Conifer/Plsc				Pima/Plsc-Sph				Pima/Sph-Clst			
Species	91	153	242	320	488	346	268	475	103	139	292	367	22	174	393	434
Graminoids																
Festuca altaica	--	--	15	--	--	--	--	--	--	+	+	--	--	--	--	--
Calamagrostis canadensis	--	--	--	--	--	[illegible]	--	--	--	3	--	--	2	+	--	--
Arctagrostis latifolia	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--
Carex aquatilis	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--	--
Pteridophytes																
Lycopodium alpinum	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Equisetum arvense	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--	--
Equisetum sylvaticum	--	--	--	--	--	--	5	--	1	--	--	+	1	--	--	10
Bryophytes																
Polytrichum juniperinum	14	10	5	30	10	3	--	+	+	1	3	--	--	2	+	--
Dicranum sp.	--	40	1	5	7	--	--	5	--	1	2	--	--	--	--	--
Hylocomium splendens	20	--	--	--	--	1	15	20	--	+	--	--	--	--	--	--
Pleurozium schreberi	40	30	70	50	65	70	70	60	65	30	40	25	10	10	30	5
Aulacomnium palustre	5	5	5	1	--	--	--	--	1	1	1	+	--	--	--	--
Sphagnum sp.	1	--	--	--	--	15	--	--	25	40	40	40	30	50	60	65
Tomenthypnum nitens	2	--	--	--	--	--	--	--	--	--	4	--	--	--	--	--
Mnium sp.	6	5	--	--	--	--	--	--	+	--	--	--	--	--	--	--
Leafy Liverworts	--	--	2	+	+	--	--	+	--	--	--	--	--	+	+	
Ptilium crista-castrensi	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--
Lichens																
Cetraria nivalis	+	+	--	--	--	+	--	--	--	--	--	--	--	--	+	--
Cetraria cucullata	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cetraria islandica	--	+	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cladina stellaris	2	20	+	10	1	1	4	2	5	20	5	10	40	30	40	25
Cladina mitis	4	2	--	--	2	2	--	30	4	5	+	--	--	+	+	--
Cladina rangiferina	--	+	--	10	2	5	--	3	5	3	1	3	5	10	5	5
Cladonia sp.	4	1	+	2	2	1	1	--	2	+	1	+	+	1	+	3
Stereocaulon sp.	--	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--
Nephroma arcticum	25	10	--	20	5	11	6	10	3	+	3	5	--	--	--	--
Peltigera aphthosa	5	--	+	--	--	+	4	+	+	+	+	--	--	--	--	--
Peltigera canina	--	--	--	1	--	--	--	10	+	+	+	--	--	--	--	--

Table 13. Site data for three stands in each of three ABLA Ct's recognized in the forest zone of the Macmillan Pass study area. Plant species cover data are in Table 14. A '*' indicates that a site photo in included in the text.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth to Water	Depth to Frost	Soil Subgroup	Terrain Type
ABLA/EMNI/POJU CT											
51.	1415.	N	8.	US	S	M	W	-.	-.	OHFP	-G.M
163.	1300.	W	35.	US	M	M	MW	-.	-.	OR	S$-A.F
259.	1360.	NE	24.	LS	M	M	I	30.	30.	RSC	GS- .B
321.	1145.	N	0.	MS	R	SM	R	-.	-.	EDYB	-M.B
ABLA/EMNI CT											
27.	1555.	SE	35.	MS	M	SX	W	-.	-.	OEB	G$-M.V
37.	1495.	S	33.	MS	M	M	MW	-.	-.	OHFP	S$-M.V
93.	1220.	SW	33.	LS	M	SM	W	-.	63.	EDYB	PS-G.B
408.	1345.	S	60.	US	M	M	W	-.	-.	ODYB	-C.V
ABLA-PIMA/CLST											
84.	1125.	SW	15.	LS	M	M	W	-.	-.	EDYB	GS-M.B
99.*	880.	W	0.	VF	M	SM	W	-.	-.	OHFP	P -G.T
369.	1165.	S	0.	LS	M	SM	W	-.	-.	EB	-M.M
473.	850.	SE	10.	LS	M	SM	MW	25.	31.		PS-M.M

Table 14. Estimated % cover of plant species in each of three predominantly ABLA community types recognized in the Macmillan Pass/Sheldon Lake region. A '+' indicates occurrence in trace amounts. Site data are presented in Table 13.

	ABLA sub-mesic community types and site numbers											
	Abla/Emni/Poju				Abla/Emni				Abla-Pima/Clst			
Species	27	37	93	408	27	37	93	408	84	99	369	473
Trees												
Abies lasiocarpa	44	38	52	46	30	12	11	17	--	--	14	--
Picea glauca	--	--	--	--	--	--	--	--	--	--	1	--
Picea mariana	--	--	--	--	--	--	--	--	13	13	0	35
Erect Shrubs												
Betula glandulosa	--	--	5	10	16	1	13	7	11	8	12	3
Ledum palustre	--	--	--	--	--	+	5	--	6	8	20	4
Salix sp.	--	--	--	--	1	--	--	+	--	--	1	--
Spiraea beauverdiana	--	--	--	--	+	--	--	--	--	--	--	--
Vaccinium uliginosum	--	--	--	--	5	+	5	15	10	--	5	1
Shepherdia canadensis	--	--	--	--	--	--	--	--	--	--	--	+
Prostrate Shrubs												
Phyllodoce empetriformis	--	--	--	--	--	+	--	--	--	--	--	--
Cassiope tetragona	--	5	3	--	3	7	--	--	--	--	--	--
Empetrum nigrum	5	1	2	3	25	30	12	10	5	1	10	--
Vaccinium vitis-idaea	--	--	+	+	+	+	8	1	5	4	4	1
Juniperus communis	--	--	--	--	1	--	--	--	--	--	--	--
Forbs												
Anemone narcissiflora	--	1	--	--	--	--	--	--	--	--	--	--
Artemisia arcticum	--	5	--	--	--	--	--	+	--	--	--	--
Epilobium angustifolium	--	1	--	--	--	--	--	--	--	--	--	--
Polygonum alaskanum	--	+	--	--	--	--	--	--	--	--	--	--
Rubus arcticus	--	1	--	--	--	--	--	--	--	--	--	--
Rubus chamaemourus	--	--	+	--	--	--	--	--	--	--	--	--
Cornus canadensis	--	--	--	--	+	+	1	2	+	+	+	2
Geocaulon lividum	--	--	--	--	--	--	+	--	--	--	--	--

Table 14 continued.

	ABLA sub-mesic community types and site numbers											
	Abla/Emni/Poju				Abla/Emni				Abla-Pima/Clst			
	27	37	93	408	27	37	93	408	84	99	369	473
Graminoids												
Festuca altaica	--	2	--	--	1	--	--	--	--	--	--	--
Hedysarm alpinum	--	1	--	--	1	--	--	--	--	--	--	--
Luzula parviflora	--	1	--	--	--	--	--	--	--	--	--	--
Pteridophytes												
Equisetum sylvaticum	--	+	--	--	--	--	--	--	--	--	--	--
Lycopodium alpinum	--	2	--	--	--	--	4	1	--	--	--	--
Bryophytes												
Polytrichum commune	--	--	--	--	--	--	10	--	20	--	--	--
Polytrichum juniperinum	25	50	40	30	+	15	7	+	--	6	+	10
Dicranum sp.	--	20	--	5	--	--	--	--	--	+	+	+
Aulacomnium palustre	25	--	+	--	--	35	15	--	1	3	--	--
Hylocomium splendens	--	20	40	--	10	--	--	10	--	--	--	--
Sphagnum sp.	--	--	10	--	--	--	--	--	--	--	--	--
Pleurozium schreberi	--	--	--	--	--	--	20	--	--	5	40	40
Mnium sp.	5	--	--	--	--	2	--	--	--	--	--	--
Leafy Liverworts	--	+	+	3	--	--	7	1	--	--	--	+
Lichens												
Cetraria cucullata	--	5	3	--	3	7	--	--	--	--	--	--
Cetraria islandica	+	+	--	+	--	1	--	--	--	--	+	--
Cetraria nivalis	--	--	--	--	--	--	--	--	--	2	4	+
Cetraria richardsonii	--	+	--	+	--	--	--	--	--	--	--	--
Cladina mitis	--	--	+	+	1	5	--	40	15	+	--	--
Cladina rangiferina	6	--	15	5	5	2	--	5	+	3	10	20
Cladina stellaris	10	--	--	40	15	15	15	15	40	85	40	60
Cladonia sp.	1	1	1	3	+	10	25	13	12	3	1	1
Stereocaulon sp.	--	2	--	30	30	35	15	--	1	2	--	--
Dactylina arctica	1	--	1	--	--	--	--	--	--	--	--	--
Nephroma arcticum	15	5	21	5	2	10	20	7	+	3	3	--
Peltigera aphthosa	+	1	--	--	--	--	--	10	+	2	+	1
Pedicularis capitata	--	--	2	--	--	--	--	--	--	--	--	1

5.3.11 Picea glauca/Ptilium crista-castrensis TCT

CI# 14, IS=.303, n=2:106,294

PIGL/PTCR is a rarely occurring community type found on level alluvial materials at low elevations. It is similar to the PIGL/HYSP alluvial ST except that *Ptilium crista-castrensis* replaces *Hylocomium splendens* as the dominant feathermoss. Forbs and grasses are numerous. Cladinae lichens and ericaceous shrubs are absent.

5.3.12 Picea glauca-Populus/Forb TCT

CI# 15, IS=.215, n=2:170,471

PIGL-POP/FORB is another rare community type occurring on mesic south-facing, steep slopes at low elevations. This community type is characterized by the presence of *Picea glauca*, deciduous trees (*Populus tremuloides, P. balsamifera, Betula occidentalis*), numerous forbs, a low cover of feather mosses, and a complete absence of lichens. This type probably succeeds to the PIGL/HYSP ST 2.2.

5.3.13 Populus balsamifera/Salix sp. TCT

CI# 16 & 17, IS=.087, n=2:80,107

POBA/SASP is a successional CT found on low-elevation gravel bars along the major rivers and streams. Soils are rapidly pervious, rapidly drained Orthic Regosols.

Populus balsamifera is the dominant tree species, and may be present in the MS, TS, or TT strata, depending on stand age. *Salix* sp. and *Alnus* sp. are common in the MS and TS strata. Forbs are numerous. Ground cover varies, again depending on stand age and openness; open stands tend to have *Stereocaulon* sp., while closed, older stands have *Dicranum* sp. and forbs.

5.3.14 Picea mariana/Empetrum nigrum TCT

CI# 4, n=1:287

This a rare submesic community occurring on a moderately well-drained Eluviated Dystric Brunisol formed on a morainal veneer. Elevation is 1150 m.

Species composition is similar to that of SASP-BEGL/EMNI. Shrubs of all growth forms dominate the site (ca. 60% cover). *Empetrum nigrum* is the dominant shrub (25%).

Vaccinium uliginosum (13%), *Lycopodium complanatum* (10%), and *Betula glandulosa* (12%) are also common. Trees are very scattered. *Picea mariana* is the dominant species (9%); however, only half of this is accounted for by TT. *Abies lasiocarpa* (TT) contributes 2% to the total tree cover. *Hylocomium splendens* is the dominant moss (12%). *Cladina stellaris* is the dominant lichen. Forbs are scarce.

5.3.15 Picea mariana/Cladina mitis TCT

Cl# 4, n=1:373

This is a rare, submesic, low-elevation community occurring on a fibric organic blanket. Water was present in the soil profile at 60 cm, frost at 90 cm. Soil pH of the rooting zone is extremely acidic (3.6). The surface of the organics (Sphagnum peat) is relatively dry and supports a dense growth of Cladinae lichens; *Cladina mitis* is dominant with 40% cover. Bryophytes present are *Polytrichum juniperinum* (40%), *Sphagnum* sp. (10%), and *Aulacomnium palustre* (10%). The LS stratum is dominated by *Ledum palustre* and *Vaccinium uliginosum*. *Empetrum nigrum* is the dominant prostrate shrub.

This is an uneven-age stand in which the TT's have achieved heights of 5.5 m at 34 years. Total tree canopy cover is less than 10%. It is possibly a successional stage following fire, though snags were not present.

5.3.16 Betula glandulosa/Ledum palustre/Polytrichum juniperinum CT

Cl# 8, IS=.107, n=10:35,79,161,175,187,212,265,315,378,417

BEGL/LEPA/POJU is a mesic to submesic community occurring predominantly on level or north-facing gentle slopes that have been recently burned. It occupies positions in the landscape from valley floors to upper slopes at elevations from 670 to 1320 m. Soils are typically moderately pervious, well-drained Brunisols, occurring on morainal material. Fibric Organic Cryosols also occur. Soil pH of the rooting zone ranges from extremely to very strongly acidic (3.6-10.7).

This community is characterized by a high cover of *Ledum palustre* (5-26%) and *Polytrichum juniperinum* (15-40%). *Betula glandulosa* (1-40%) and *Vaccinium uliginosum* (2-20%) are always present. Cladinae and Cladonae lichens are also always present. *Dicranum* sp. is the most common moss, though feathermoss and peatmoss may be present. Regeneration is normally *Picea mariana*, though *Abies lasiocarpa* occurs on the higher elevation sites.

Plate 22. BEGL/LEPA/POJU CT, Site 35, Hess River, (63° 22′ 60″ N, 131° 40′ 00″ W.) Elevation - 1050 m. A burned community with *Picea mariana* being the regenerating species. *Betula glandulosa* (12% cover) and *Ledum palustre* (15%) are the dominant shrubs. Soil is an Orthic Cryosol with frost present at 40 cm. Date sampled - June 19, 1981.

5.3.17 Salix sp./Forb CT

CI# 12, IS=.198, n=7:47,119,248,283,313,314,466

The SASP/FORB CT occurs on recently burned, mesic, south-facing slopes, ranging in elevation from 835 to 1450 m. Soils are typically moderately pervious, moderately-well drained Brunisols, occurring over colluvial or bedrock parent materials. Soil pH of the rooting zone ranges from extremely acidic to strongly acidic (3.8-5.3).

This CT is characterized by MS and TS *Salix* sp. having cover values ranging from 15 to 70%. The understory is dominated by forbs, the most numerous being *Aconitum delphinifolium, Anemone* spp., *Cornus canadensis, Epilobium angustifolium, Lupinus arcticus, Mertensia paniculata, Pedicularis labradorica, Pyrola asarifolia, and Senecio lugens.* Low shrubs that often occur are *Potentilla fruticosa, Ledum palustre,* and *Ribes triste*. Cladinae and Cladoneae lichens, if present, occur in trace amounts. *Populus balsamifera, P. tremuloides,* and *Betula occidentalis* may occur. Regeneration is either *Abies lasiocarpa* or *Picea glauca*. Feathermosses, *Polytrichum juniperinum,* and *Dicranum* sp. may occur, usually with low cover.

Plate 23. SASP/FORB CT, Site 119, W of Niddery Lake, (63° 21' 00' N, 131° 50' 07" W). Elevation - 1100 m. A very lush site on a S-facing slope. Burned snags were present. The TT willows are *Salix bebbiana* (30% cover) and *Salix glauca* (20%). *Ledum palustre* (15%) and *Vaccinium uliginosum* (20%) were the dominant LS's. The ground was carpeted by *Linnaea borealis* (50%). Date sampled - July 6, 1981.

5.3.18 Populus tremuloides/Polytrichum juniperinum TCT

Cl# 9, IS=.284, n=2: 118,402

POTR/POJU is a submesic to subxeric community type, occurring on recently burned, south-facing, moderately to steeply sloping sites, between 1000 and 1160 m. Soils are well-drained Orthic Eutric Brunisols or Orthic Regosols formed on colluvial or bedrock parent material.

This community is characterized by a high cover of deciduous trees. *Populus tremuloides* is most common (15-45% cover, but *Betula occidentalis* (TT) may also be present with a relatively high cover . Ericaceous shrubs are common, but have with low cover values. Forbs are numerous. *Polytrichum juniperinum* is the dominant moss (15-50% cover); other species occur only in trace amounts. Cladoniae lichens are present in trace amounts.

5.3.19 Ledum palustre/Peltigera aphthosa TCT

Cl# 8, IS=.366, n=2:416,470

LEPA/PEAP is a loose association of two burned sites characterized by a dominance of *Ledum palustre* in the LS stratum and a high ground cover of *Peltigera aphthosa*. Deciduous trees (*Betula occidentalis, Populus tremuloides*) are dominant in the TT stratum. *Salix* sp. is present with a low cover value in the MS stratum. Forbs are numerous. Feathermosses and Cladoneae lichens are present with a low cover value. Floristically this CT most closely resembles Begl/Lepa/Poju.

The two sites occur on low-elevation (820-860m), occurring on rapidly to very rapidly drained, rapidly pervious Brunisols, formed on hummocky glacio-fluvial parent material.

5.3.20 Betula glandulosa-Salix sp./Festuca altaica TCT

Cl# 13, IS=.266, n=83,138,286

BEGL-SASP/FEAL is a mesic CT occurring primarily on very steep south-facing slopes, that have been recently burned. Soils are moderately-well to well-drained, moderately pervious Dystric Brunisols, occurring on colluvial parent material. The pH of the rooting zone is extremely to strongly acidic (3.8-5.2).

Festuca altaica is the most dominant species in the understory with 10 to 30% cover. Forbs (*Epilobium angustifolium, Cornus canadensis, Lupinus arcticus, Petasites frigidus*) are numerous. *Lycopodium alpinum and L. annotinum* are usually present. *Betula glandulosa* and *Salix* sp. dominate the MS statum. *Abies lasiocarpa, Picea glauca* and *Betula occidentalis* may occur in the TT stratum.

5.3.21 Salix sp.-Betula glandulosa/Empetrum nigrum TCT

Cl# 4, n=1:291

This is a rare, old-burn community where the dominant species in the ground cover stratum is *Empetrum nigrum* (35%), though *Cladonia* sp., *Dicranum* sp., *Polytrichum juniperinum* and *Nephroma arcticum* also occur with relatively high cover values (15-20%). The TS and MS strata are dominated by *Salix* sp. and *Betula glandulosa*. The LS stratum is dominated by *Ledum palustre*. Regeneration is *Picea mariana*.

This is a mesic community occurring on a moderately pervious, imperfectly-drained Orthic Dystric Brunisol at 1130 m on a level site.

5.4 DECORANA Ordination Results

5.4.1 Distribution of Communities and Sites

The 245 forest stands plotted against the X and Y axes of the Decorana ordination are shown in Figures 10 - 12. The XY coordinates of the sites are given in Appendix VII. The first, second and third axes were found to represent complex-gradients (Fig. 9). (All correlations listed below are significant at alpha=.05, a '*' indicates significance at alpha=.01. Soil nutrient variables discussed are for the rooting zone only.

The X-axis, accounting for 44% of the variation in the data, was positively correlated (r=.49*) with soil pH, and but weakly correlated with slope angle (r=.30*), aspect (r=.24*), slope X aspect (r=.26), Mg (r=.35*), Ca (r=.23*), and % clay (r=.25*). The Y-axis, accounting accounting for 31% of the residual variation, or 21% of the total variation, was significantly positively correlated with soil drainage (r=.43*), ecological moisture (r=.50), elevation (r=.64*), and % sand (r=.34*), and negatively correlated with pH (r=-.32), C/N ratio (r=-.23*), Mg (r=-.33*), and Ca (r=-.31*). The Z-axis, accounting for

6.4% of the total variation was also significantly positively correlated with drainage (r=.22*), but was negatively correlated with elevation (r=.18*). Axis 4 accounted for 5.7% of the total variation in the data but was not significantly correlated to any of the parameters examined, and was, therefore, not used.

There was considerable overlap among communities when drawn on the XY ordination field (Figs. 10-12). The stands nearest the origin are clustered into the PIMA/SPH-CLST and PIMA/SPH-PLSC CT's, occurring on low elevation, low pH, poorly drained sites (Fig. 10). These two CT's occupy similar positions along the X-axis, which represents a gradient from low to high pH, but PIMA/PLSC-SPH community has a much broader amplitude on the Y-axis, which represents a complex-gradient from poorly drained to well-drained soils, and from low to high elevations (Fig. 9)

Continuing up the Y-axis, the CT's intergrade with one another, with *Sphagnum* and *Picea mariana* becoming less dominant as drainage improves and elevation increases, and being replaced by *Abies lasiocarpa*, *Pleurozium schreberi*, and *Cladina stellaris*. ABLA-PIMA/CLST occupies the extreme left of the X-axis, halfway up the Y-axis, indicating that it occurs on mid-elevation, mesic, extremely acidic sites (Fig 11).

Along the pH gradient (X-axis), near the lower end of the Y-axis, the following CT's and ST's intergrade with each other as pH increases: PIMA/SPH, PIMA/PLSC, PIGL/PLSC, PIMA/HYSP-SPH, PIMA/HYSP, PIGL/HYSP, PIGL/PTCR, and POBA/SASP. ABLA/HYSP occupies a position similar to that of PIGL/HYSP along the pH gradient, but occurs on better-drained soils, at higher elevations, and lies at the extreme top right of the ordination field. The placement of the PIGL communities on the ordination axes is shown in Figure 12. The nutrient status of the communites is summarized in Tables 15 - 18.

The X-axis is weakly correlated with slope, aspect and slope x aspect, suggesting that the communities (PIGL) laying to the right occur on more sloping, southerly-facing sites than those laying to the left (PIMA). Slope-aspect relationships of the major communities are illustrated in Figure 13.

The burned stands did not appear on the ordination as outliers, but are grouped together with the mature stands. The SASP/FEAL and SASP/FORB communities occurred in the same sector of the ordination field as the PIGL/HYSP community and, based on species composition and site factors, one can predict that they will succeed to this community.

The BEGL/LEPA/POJU burn community overlaps several communities, occurring at the lower left of the XY field. The direction of succession of these stands is variable, depending on site conditions. However, *Picea mariana* is likely to be the dominant tree species, and *Pleurozium schreberi*, *Sphagnum*, or *Cladina stellaris* can be expected to be the dominant ground cover, in the climax communities.

The LEPA/PEAP community falls within the area occupied by the *Hylocomium*-dominated communities, and will probably succeed to either PIMA/HYSP or PIGL/HYSP.

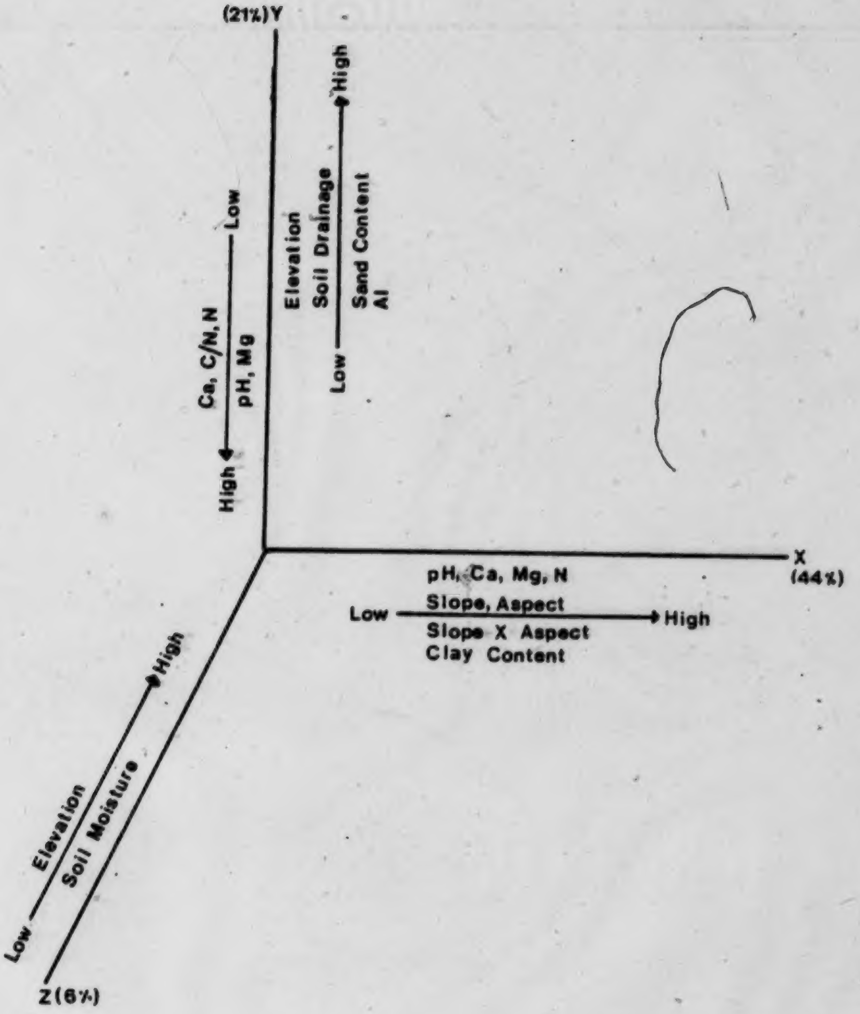

(21%)Y
High
Ca, C/N, N
pH, Mg
Low
Low
Elevation
Soil Drainage
Sand Content
Al
High
X
(44%)
pH, Ca, Mg, N
Slope, Aspect
Low
High
Slope X Aspect
Clay Content
Low
Elevation
Soil Moisture
High
Z(6%)

Figure 9. Forest zone - A diagramatic representation of the first three axis of the DECORANA ordination and the correlated environmental variables. The numbers in parenthesis are the axes eigenvalues which indicate the amount of variation in the vegetation data accounted for by each axis.

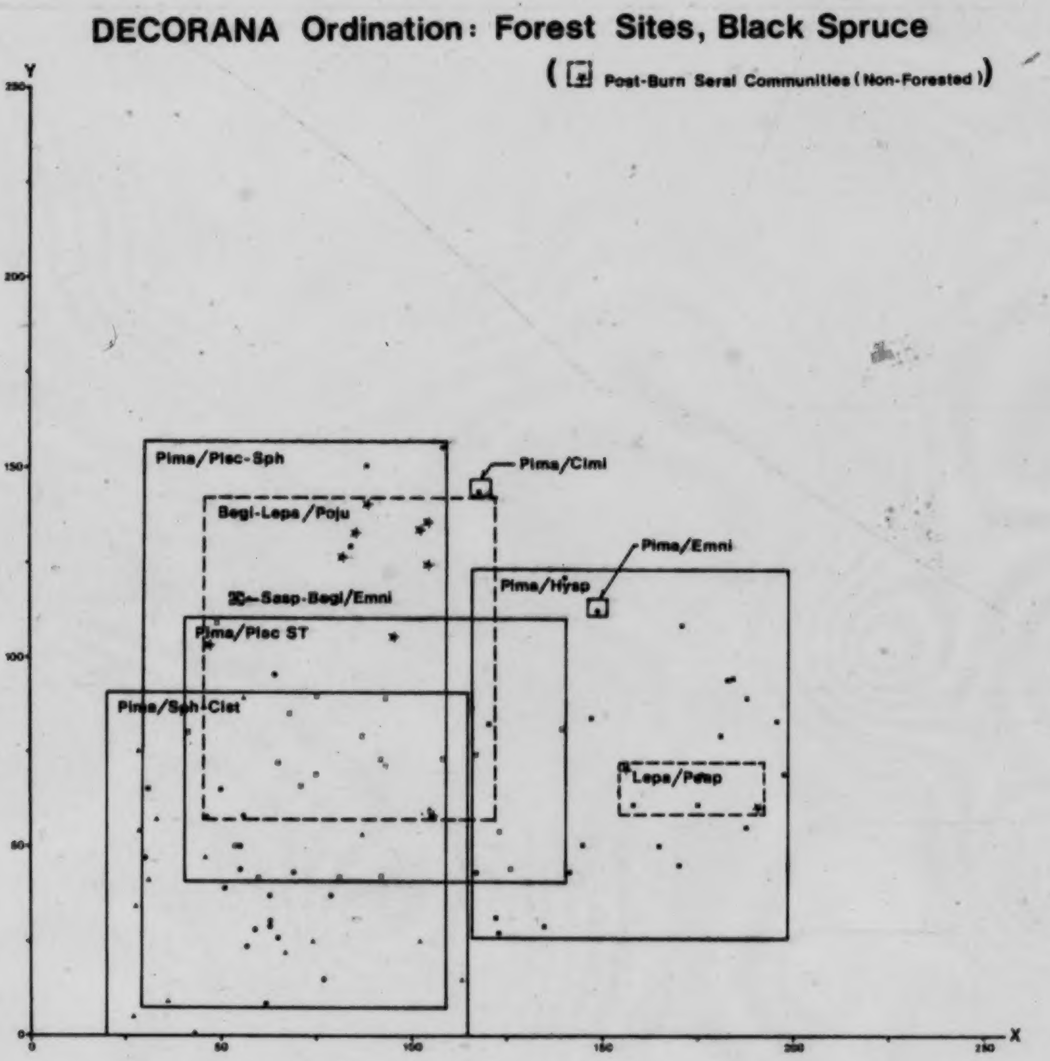


Figure 10. Location of the Black spruce CT's, TCT's and ST's on the DECORANA ordination field. It is likely that the post-burn seral communities will succeed to black spruce communities. The axes units are the average standard deviation of species turnover. Site coordinates are in Appendix VI.

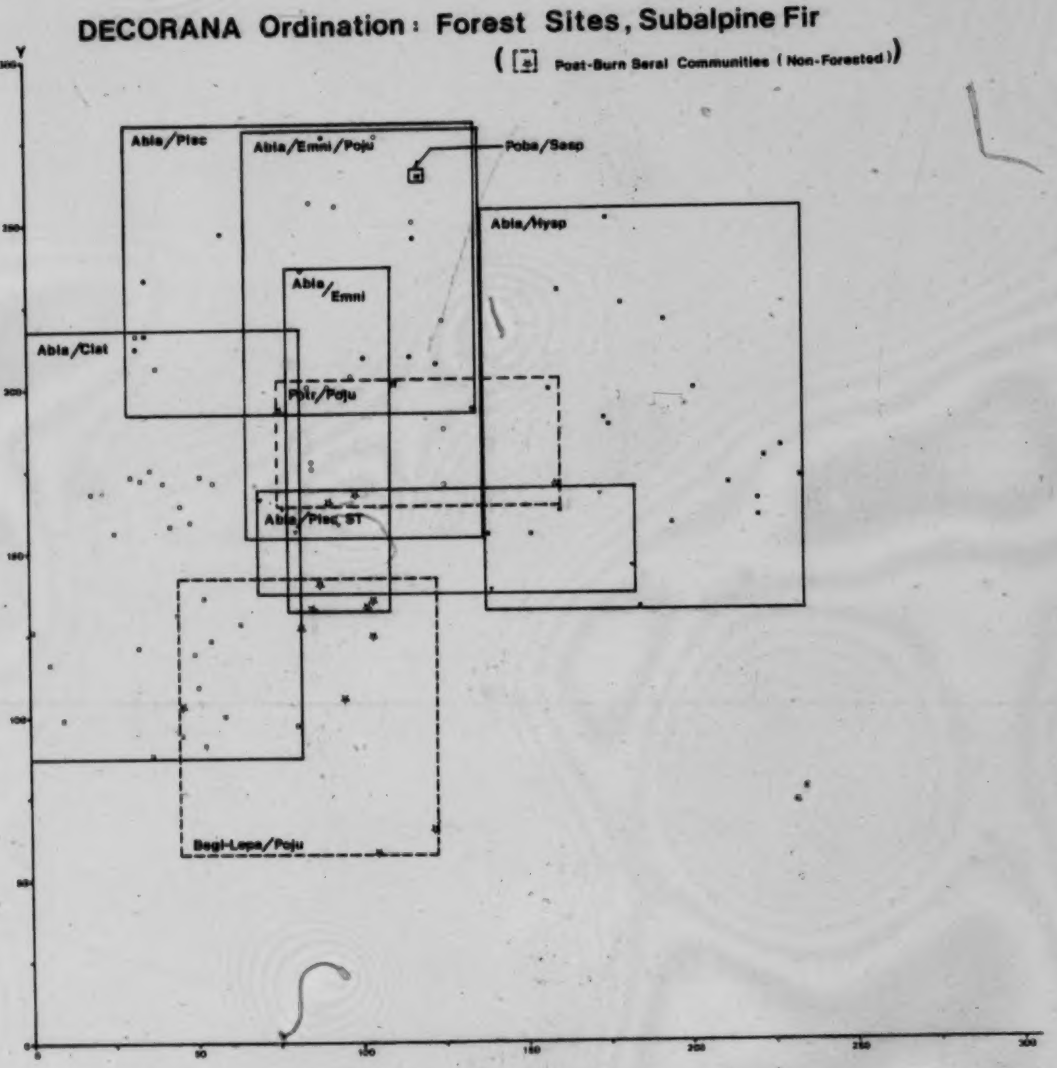


Figure 11. Location of the Subalpine fir CT's, TCT's, and ST's, and seral communities likely to succeed to subalpine fir on the DECORANA ordination axis. The axes units are the average standard deviation of species turnover. Site coordinates are in Appendix VI.

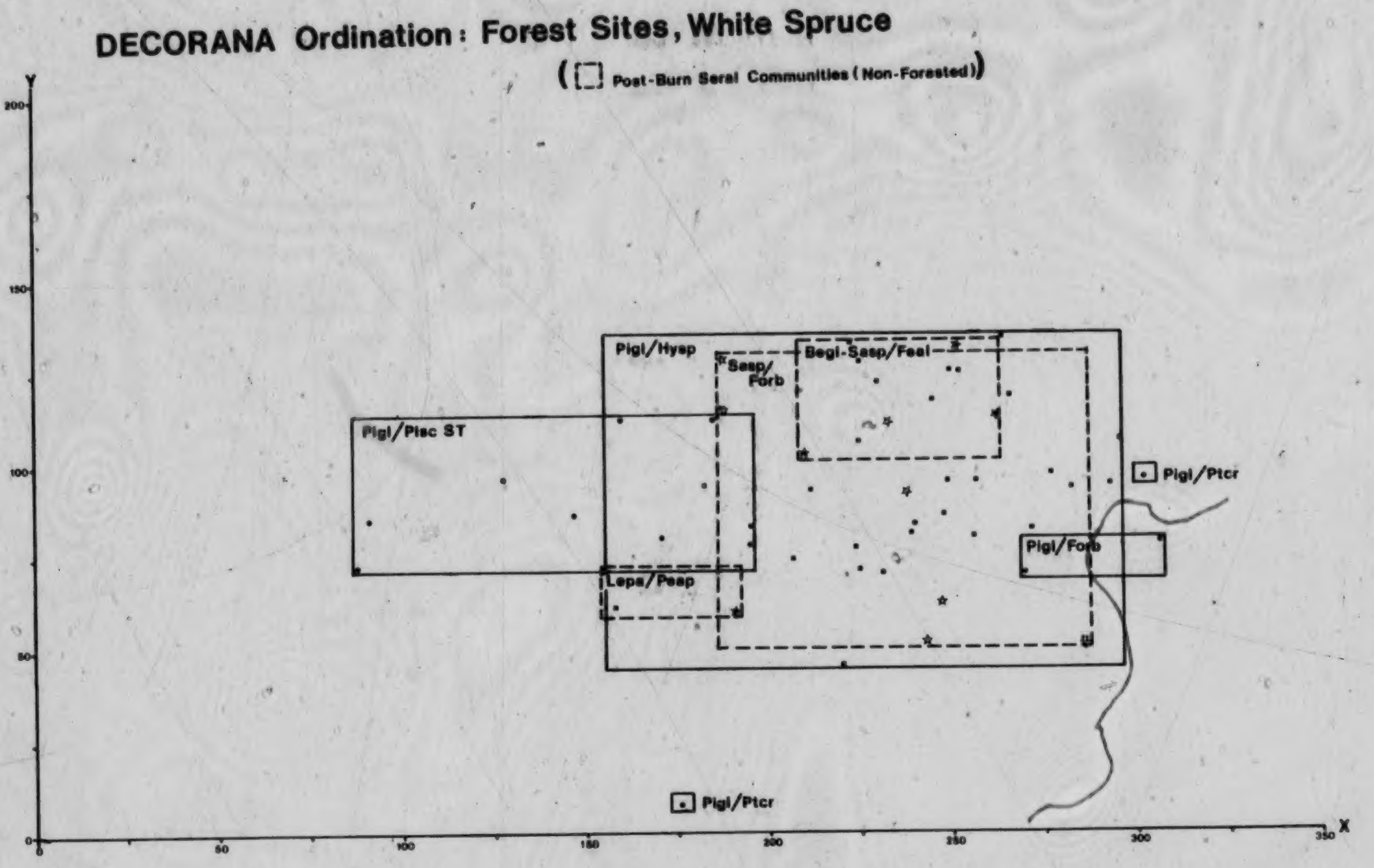
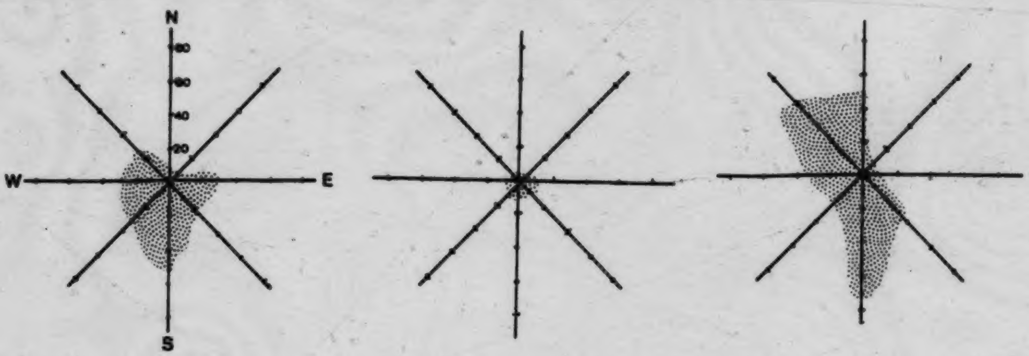
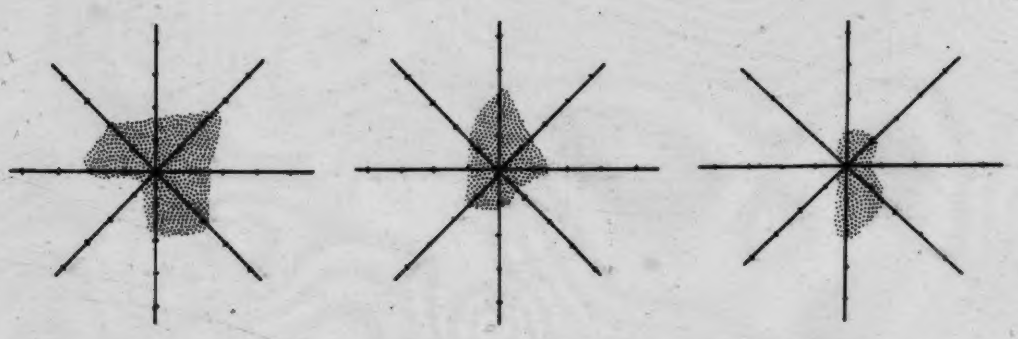


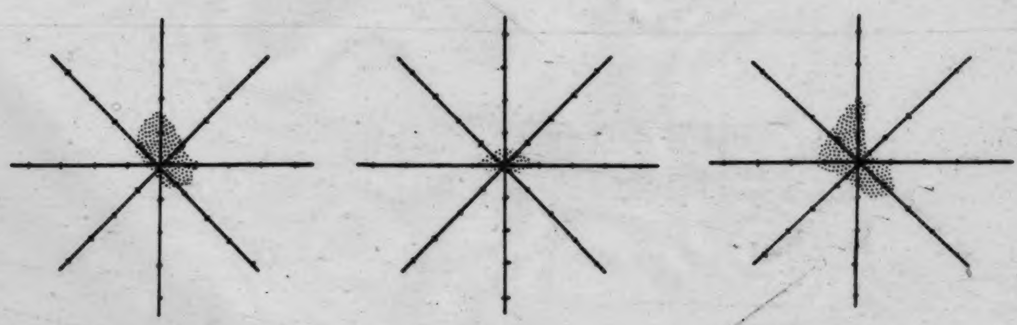
Figure 12. Location of the White spruce CT's, TCT's and ST's, and seral communities likely to succeed to white spruce on the DECORANA ordination axes. The axes units are the average standard deviation of species turnover. Site coordinates are in Appendix VI.



PIGL/HYSP-Morainal PIGL/HYSP-Alluvial ABLA/PLSC



ABLA/HYSP PIMA/HYSP CONIFER/PLSC



PIMA/PLSC-SPH PIMA/SPH-CLST ABLA-PIMA/CLST

Figure 13. The aspect and slope (%) distribution of the major forested community types. The shaded areas represent the range of slope and aspect distribution of the sites within the community.

Community	No. of Samples	% Nitrogen Mean and S.D.		C/N Ratio	Community	No. of Samples	Ca (meq/100 g) Mean and S.D.	
Begl/Clst	12	0.12±0.03	A	11.98±3.74	Abla-Pima/Clst	9	0.27±0.17	A
Begl/Moss	9	0.11±0.04	A	10.31±1.90	Abla/Plsc ST	4	0.43±0.37	A
Abla-Pima/Clst	9	0.11±0.04	A	11.26±5.43	Begl/Clst	12	0.45±0.26	A
Pima/Plsc-Sph	5	0.16±0.06	A B	11.52±4.52	Begl/Moss	9	1.16±2.09	A
Abla/Plsc ST	4	0.17±0.06	A B	14.22±2.66	Pima/Plsc-Sph	5	1.24±1.43	A
Pigl/Plsc ST	4	0.17±0.12	A B	13.55±4.34	Abla/Hysp	6	2.62±3.40	A B
Abla/Hysp	6	0.18±0.09	A B	10.50±3.37	Pigl/Plsc ST	4	5.87±7.02	B
Pigl/Hysp	4	0.22±0.08	B	13.83±1.34	Pima/Hysp	3	6.30±8.26	B
Pima/Hysp	3	0.28±0.22	B	15.46±1.50	Pigl/Hysp	5	6.40±2.48	B

Table 15. Duncan's Multiple Range Test - Nutrients in the B horizons. Communities with the same letter are not significantly different from each other. The C/N ratio is not significantly different between any of the communities.

Community	No. of Samples	Mg (meq/100 g) Mean and S.D.		Community	No. of Samples	Al (meq/100 g) Mean and S.D.	
Abla-Pima/Clst	9	0.02±0.07	A	Pigl/Hysp	4	1.17±0.39	A
Begl/Clst	12	0.03±0.05	A	Pigl/Plsc ST	2	1.20±0.00	A B C
Begl/Moss	9	0.24±0.44	A B	Begl/Clst	11	1.78±0.75	A C
Abla/Plsc ST	4	0.30±0.47	A B C	Begl/Moss	8	1.85±1.19	A B C
Pima/Plsc-Sph	5	0.60±0.85	A B C	Pima/Hysp	2	1.90±1.27	A B C
Abla/Hysp	6	1.15±1.42	A B C	Abla-Pima/Clst	9	2.13±1.43	A B C
Pigl/Hysp	5	1.94±1.17	B C D	Pima/Plsc-Sph	4	3.03±1.42	A B C
Pima/Hysp	3	2.40±3.81	B C D	Abla/Plsc ST	4	3.56±1.53	B C
Pigl/Plsc ST	4	3.15±3.87	B C D	Abla/Hysp	3	3.73±3.22	B C

Table 16. Duncan's Multiple Range Test - Nutrients in the B horizons. Communities with a letter in common are not significantly different from each other.

Community	No. of Samples	% Nitrogen Mean and S.D		C/N Ratio
Begl/Clst	12	0.09±0.03	A	7.89±3.22
Abla-Pima/Clst	11	0.10±0.05	A	10.25±4.25
Abla/Hysp	6	0.12±0.09	A	10.75±3.46
Abla/Plsc ST	3	0.12±0.03	A	8.20±3.30
Pima/Plsc ST	5	0.12±0.04	A	11.90±5.00
Pigl/Plsc ST	6	0.13±0.07	A	13.08±2.80
Pima/Plsc-Sph	5	0.15±0.08	A	10.82±2.05
Pima/Hysp	5	0.22±0.20	AB	11.82±3.26
Pigl/Hysp	11	0.31±0.19	B	15.66±4.11

Table 17. Duncans Multiple Range Test-% Total Nitrogen in the C horizon. Communities with a letter in common are not significantly different from each other.

Community	No. of Samples	Calcium (meq/100 g) Mean and S.D.		Community	No. of Samples	Magnesium (meq/100 g) Mean and S.D.	
Begl/Clst	12	0.83±0.95	A	Begl/Clst	12	0.17±0.24	A
Abla/Hysp	6	2.22±2.16	A B	Abla/Hysp	6	0.37±0.38	A C
Abla-Pima/Clst	11	2.41±3.28	A B	Abla-Pima/Clst	11	0.55±0.83	A C
Pima/Plsc-Sph	5	2.42±1.90	A B	Pima/Plsc-Sph	5	0.58±0.61	A B C
Pima/Plsc ST	5	3.12±2.33	A B	Abla/Plsc ST	3	0.67±0.74	A B C
Abla/Plsc ST	3	4.13±2.72	A B	Pima/Plsc ST	5	0.76±0.74	A B C
Pigl/Plsc ST	6	5.48±4.52	A B	Pigl/Plsc ST	6	1.87±2.13	B C
Pima/Hysp	5	7.16±2.12	B	Pima/Hysp	5	1.90±0.62	B C
Pigl/Hysp	11	13.98±10.50	C	Pigl/Hysp	10	3.18±1.87	D

Table 18. Duncan's Multiple Range Test - Nutrients in the C horizon.
Communities with a letter in common are not significantly different from each other.

5.4.2 Distribution of Species

Figure 14 shows the distributional centers of the species on the XY field of the DECORANA ordination. The axes represent the same complex-gradients as in the stand ordination.

The three major coniferous tree species are widely separated on the ordination field. *Picea mariana* occurs nearest the origin of the XY axes, suggesting that maximum cover is acheived on poorly drained, low-elevation, nutrient-poor sites. Chi-square tests of independence verify this (Table 19). *Picea mariana* , though occurring on a wide range of site conditions, is not independent of the site variables. It occurs on very poorly to well-drained soils, but more often than expected by chance on very poorly to imperfectly drained soils. *Picea mariana* also occurs more often than expected on Cryosolic soils, and on organic and morainal parent materials. Its presence also depends on slope position, occurring more often on valley floors and lower slopes; and slope angle, where it occurs more often on level and gently-sloping sites. Its presence is independent of slope aspect. *Picea mariana* cover is significantly, negatively correlated with elevation (r=-.48*).

Picea glauca , in contrast, occurs near the far end of the X-axis, indicating that it prefers better drained, more nutrient-rich sites, with more neutral pH's than *Picea mariana* . As with *Picea mariana* , *Picea glauca* occurs over a wide range of site conditions, but its distribution is not necessarily independent of these site conditions. In contrast to *Picea mariana* , it occurs significantly more often than expected by chance on level, south, southwest, and southeast-facing slopes (Table 19). While it occurs over a wide elevational range (650-1485 m, x=1070 m), it occurs significantly more often than expected on valley floors and lower slopes. Its cover is weakly and negatively correlated with elevation (r=-.26*). It also occurs significantly more often on than expected on Cryosolic soils and alluvial parent material, but its presence is independent of soil drainage.

The third conifer species, *Abies lasiocarpa* , which occurs in 54% of the stands, falls between *Picea mariana* and *Picea glauca* on the X-axis, but well above them, halfway up the Y-axis. The later axis represents a complex-gradient of increasing elevation, better soil drainage, and decreasing pH. *Abies lasiocarpa* presence depends upon slope position and steepness; it occurs significantly more often than expected on gentle to steeply sloping mid and upper slopes, and rarely on valley floors (Table 19). The cover of *Abies* *lasiocarpa* is strongly correlated with elevation (r=+.60*). Its presence appears to be independent of aspect, for it occurs equally often on NE- and SW-facing slopes. This species occurs on all soil types and parent materials, but more often than expected on Brunisols, Podzols, Regosols, and colluvial or morainal materials. The presence of *Abies lasiocarpa* appears to be largely independant of soil nutrient status. There is no significant difference between sites with and sites without *Abies lasiocarpa* with regard to Ca, Mg, and C/N.

Shrubs which have been examined are *Betula glandulosa* , *Cassiope tetragona* , *Empetrum nigrum* , *Vaccinium uliginosum* , *Vaccinium vitis-idaea* and *Ledum palustre* . *Betula glandulosa* is the most ubiquitous shrub species, occurring in 73% of the sites; it seems independent of most site and soil parameters examined. It does occur more often than expected, however, on level and northerly-facing sites. On the XY ordination field, it occurs midway along the X-axis, and near the bottom of the Y-axis, in the vicinity of *Ledum palustre* and other ericaceous shrubs.

Chi-square tests of independance demonstrate that the majority of the ericaceous species have a tendency to occur on low-elevation sites, independent of aspect, while *Cassiope tetragona* occurs more often than expected on high-elevation, north-facing sites (Table 19). The positioning of these species on the ordination field also indicates this.

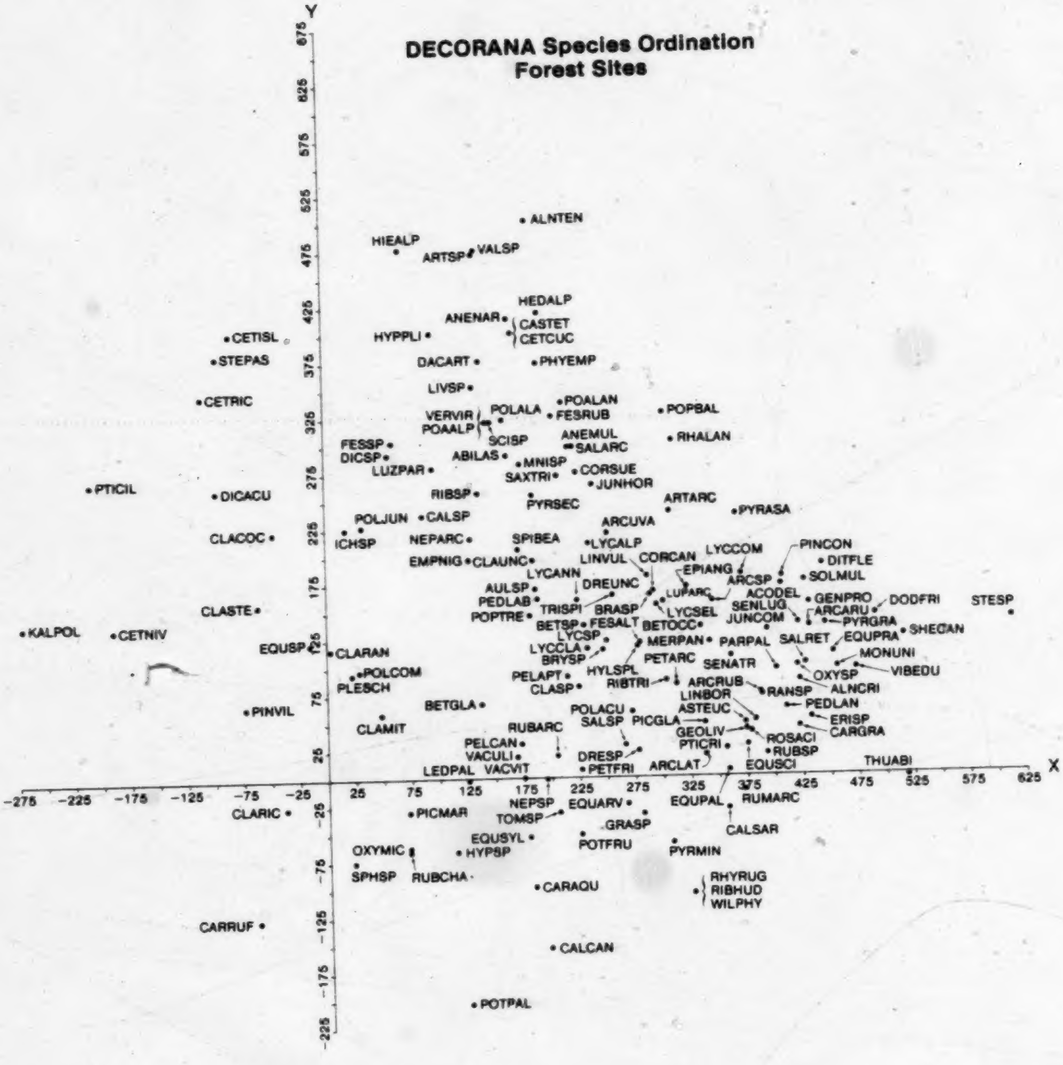


Figure 14. DECORANA ordination of species in the 246 sites located in the forest zone. The X-axis was most strongly correlated with increasing soil pH and nutrient status, the Y-axis with increasing elevation and soil drainage. The labels are the first three letters of the genus and species. Complete species names are in Appendix VII. Axes scales are in units of average standard deviations of species turnover.

	Soil G.G.		Parent Material		Soil Drainage		Slope		Position		Aspect		Elevation
Pigl	D	Cryosols	I		D	Imperfectly	D	level	I		D		-
Pima	D	Cryosols	D	Morainal Alluvium	I		D	level gentle	D	lower slope valley floor	I		-
Abla	D	Brunisols Podzols Regosols	D	Morainal Colluvium	I	Mod well well	D	moderate to steep	D	mid upper slope			+
Begl	I		D	Lacustrine Morainal	I		D	level gentle	D	lower slope valley floor	I		-
Sasp	D	Cryosols Gleysols	I		D	poorly imperfectly	I		I		I		=
Legr	D	Cryosols	D	Lacustrine Morainal Organic	D	poorly imperfectly	D	level gentle	D	lower slope valley floor	I		=
Vaul	D	Cryosols Gleysols	D	Morainal Organic	D	imperfect to very poor	D	level to gentle	D	lower slope valley floor	D	level east north	-
Vavi	D	Cryosols	D	Glacio-fluvial Lacustrine Morainal Organic	D	imperfectly to very poorly	D	lever to gentle	D	lower slope valley floor	I		-
Emni	I		I		I		D	moderate	D	lower and mid slopes	D	north N.E. east	+
Cate	D	Brunisols Podzols	I		I				D	mid + upper slopes	D	west N.W. north N.E	+
Eqsy	D	Cryosols Brunisols	D	Alluvium Lacustrine Morainal Organic	I	imperfectly to very poorly	D	gentle to moderate	D	lower slope	I		-

Table 19. Vascular Species, Test of Independence, Forested Zone. Factors listed are those where the species occurs more often than expected by chance. Elevation indicates whether the mean elevation of species occurrence was equal to the mean elevation of the zone.

The major feathermosses, *Hylocomium splendens* and *Pleurozium schreberi* , are similar with regards to distribution of site factors, being independent of all those examined, except moisture. Both species occur more often than expected on poorly to imperfectly drained soils (Table 20). The cover of *Pleurozium schreberi* is also weakly and negatively, correlated with elevation. While these two species occur on similar locations in the landscape, they differ with regards to soil nutrient status. The concentrations of Ca and Mg are significantly higher on sites where *Hylocomium splendens* is present than on sites where it is absent. Sites with *Pleurozium schreberi* have lower, but not significantly, values of Ca and Mg than sites without. In addition, the values of Ca and Mg are significantly lower under stands where *Pleurozium schreberi* is present, than where *Hylocomium splendens* is present. This difference in soil nutrient status is reflected by the species and site ordinations where *Hylocomium splendens* and *Hylocomium splendens* -dominated communities occur further along the X-axis, which represents increasing nutrient status, than do *Pleurozium schreberi* and *P. schreberi*-dominated communities.

The two common foliose lichens, *Peltigera aphthosa* and *Nephroma arcticum* , occur over a wide range of site conditions, but have significant preferences. *Nephroma arcticum* , whose cover is weakly but significantly correlated with elevation, has a marked preference for mid- and upper-slope, northerly-facing sites. This is in contrast to *Peltigera aphthosa* , whose cover is not correlated to elevation, and has no apparent preference for slope position, but occurs more often than expected on southerly-facing slopes (Table 20).

The three major Cladinae lichens, *Cladina stellaris* , *C. mitis*, and *C. rangiferina* all occur near the origin of the X and Y axes, indicating that they are most abundant on low-elevation, nutrient-poor, acidic, poorly drained sites. This is verified by the Chi-square tests of independence (Table 20). Cladinae lichens are commonly associated with dry site conditions, but within the study area, they are often associated with *Picea mariana* and *Sphagnum* sp. , where the lichen occurs on the dry microsites offered by the surface of the Sphagnum hummocks.

	Soil G.G.		Parent Material		Soil Drainage		Slope		Position		Aspect		Elevation
Hysp	D	Cryosols Gleysols	I		D	imperfectly to poorly	D	moderate steep	I		I		=
Plsc	I		I		D	mod well to poorly	D	level to gentle	I		I		-
Sph	D	Cryosols Gleysols	I	Lacustrine Organic	D	imperfectly to very poorly	D	level to gentle	D	lower slope valley floor	D	level, NW,north NE,east	-
Clmi			I		I		I		I		I		-
Clst	I		D	Morainal Glacio-fluvial Organic	I		D	level to	I		I		=
Clra	D	Cryosols	I		I		I		I		D	northwest north northeast level	=
Stsp	D	Brunisols Podzols	I		D	mod well to well	D	moderate	I		I		=
Near	I		D	Morainal	I		I		D	lower slope mid slope apex	D	north northeast east	+
Peap	I		D	Colluvium	I		D		I		I		=

Table 20. Test of Independence Non-vascular Species in the Forested Zone.
I - indicates that the species occurs independently of the environmental factor in question
D - indicates that its distribution is not independent. Enviornmental factors listed are those where the species occurs more often than expected.
Elevation indicates whether the mean elevation of of the species occurrence was higher, lower, or equal to the mean elevation of the zone.

6. Non-Forested Below Treeline

6.1 Overview

The vegetation comprising this group consists of stable communities that occur below treeline, but which have less than 10% tree cover, often due to either a shortage or excess of soil moisture. The majority of the stands occur on level or gently sloping valley floors, and occasionally lower slopes, from 760 to 1480 m.

The flora of the 102 stands consists of 123 vascular species in 59 genera, and 44 non-vascular species in 26 genera. In terms of major-growth forms there are 6 trees, 19 erect shrubs, 8 prostrate shrubs, 60 forbs, 22 graminoids, 8 pteridophytes, 20 lichens, and 24 bryophytes.

The communities within this group can be placed into two major ecological subgroups: mesic to subxeric communities that occur predominantly on moderately well to rapidly drained glacio-fluvial and morainal material; and mesic to hygric communities that occur predominantly on very poorly to imperfectly drained alluvial and organic material. The species compositions of these two subgroups are drastically different (See Figure 17)

In the mesic-xeric subgroup, the major erect shrub is *Betula glandulosa* . Prostrate shrubs are not common. The ground is covered with an almost continuous bryoid mat, dominated by *Cladina stellaris* . *Polytrichum juniperinum* is the dominant bryophyte in the mat. Forbs are not common.

Within the mesic-hygric subgroup fens and grasslands are common. *Salix* spp. are the major erect shrubs. Porsild (1951) found that *Salix barclayi* and *S. pulchra* are the common willows in these habitats. Less common shrubs are *Betula glandulosa* , *Ledum palustre* , *Potentilla fruticosa* , and *Vaccinium uliginosum* . Prostrate shrubs are rare. *Festuca altaica* and *Carex aquatilis* are the dominant graminoids. Others that commonly occur are *Calamagrostis canadensis* and *Arctagrostis latifolia* . *Carex rostrata* is common in the vicinity of Sheldon Lake. Porsild (1951) recorded it occurring there, but did not find it further north. In the present study it was not found further north, but it did occur further east on a tributary of the Prevost River. Forbs, which usually occur in association with *Festuca altaica* are numerous. The dominant bryophytes are *Sphagnum* sp. , *Tomenthypnum nitens* , and *Aulacomnium palustre* . Lichens are not common.

6.2 Cluster Analysis of Stands

Results of the SAHN complete linkage cluster analysis based on total species cover data are shown in Figure 15. Locations of the major clusters on the DECORANA ordination field are shown in Figure 17. Since environmental factors may vary within a cluster each cluster may contain several community types or subtypes. Groups of four or more sites are recognized as community types (CT's), whereas smaller groups are regarded as tentative community types (TCT's). Site and species cover data for four sites in each of the CT's are presented in Tables 21 - 24.

Clusters 1 to 4 consist almost exclusively of mesic to xeric sites characterized by a high cover of MS *Betula glandulosa* and a continuous bryoid mat. The separation between the clusters is based mainly on the relative abundance of lichens and mosses.

Cluster 1 (IS=.197) which consists of 7 *Betula glandulosa* / *Hylocomium splendens* dominated sites, is comprised of one CT and two TCT's, each of the latter having a single site.

Cluster 2 (IS=.507) is much tighter and consists of 11 sites where *Pleurozium schreberi* is the dominant bryophyte.

Cluster 3 (IS=.474) consists of 4 sites. *Polytrichum juniperinum* is the dominant bryophyte and *Cladina stellaris* is absent.

Cluster 4 (IS=.136) consists of 32 *Betula glandulosa* / *Cladina stellaris* stands that can be considered a CT and one TCT, dominated by *Festuca altaica* .

Clusters 5 to 13 consist of loose groupings of mesic to subhydric sites dominated by either graminoids or *Salix* spp.. Cluster 5 (IS=.156) is a loose grouping of stands characterized by a high cover of *Salix* sp. . It contains two distinct communities.

Cluster 6 (IS=.469) consists or four stands, dominated by *Salix* sp. and *Hylocomium splendens* . It contains one CT and one TCT.

Cluster 7 consists of only one forb-dominated site occurring on an alluvial gravel bar. It is most similar to Clusters 5 and 6.

Cluster 8 (IS=.145) which is most similar to Clusters 9 and 10, consists of 13 stands characterized by a high cover of *Carex aquatilis* . It consists of a major community type and a TCT. It is difficult to distinguish plots in this cluster from those in Clusters 5 and 10.

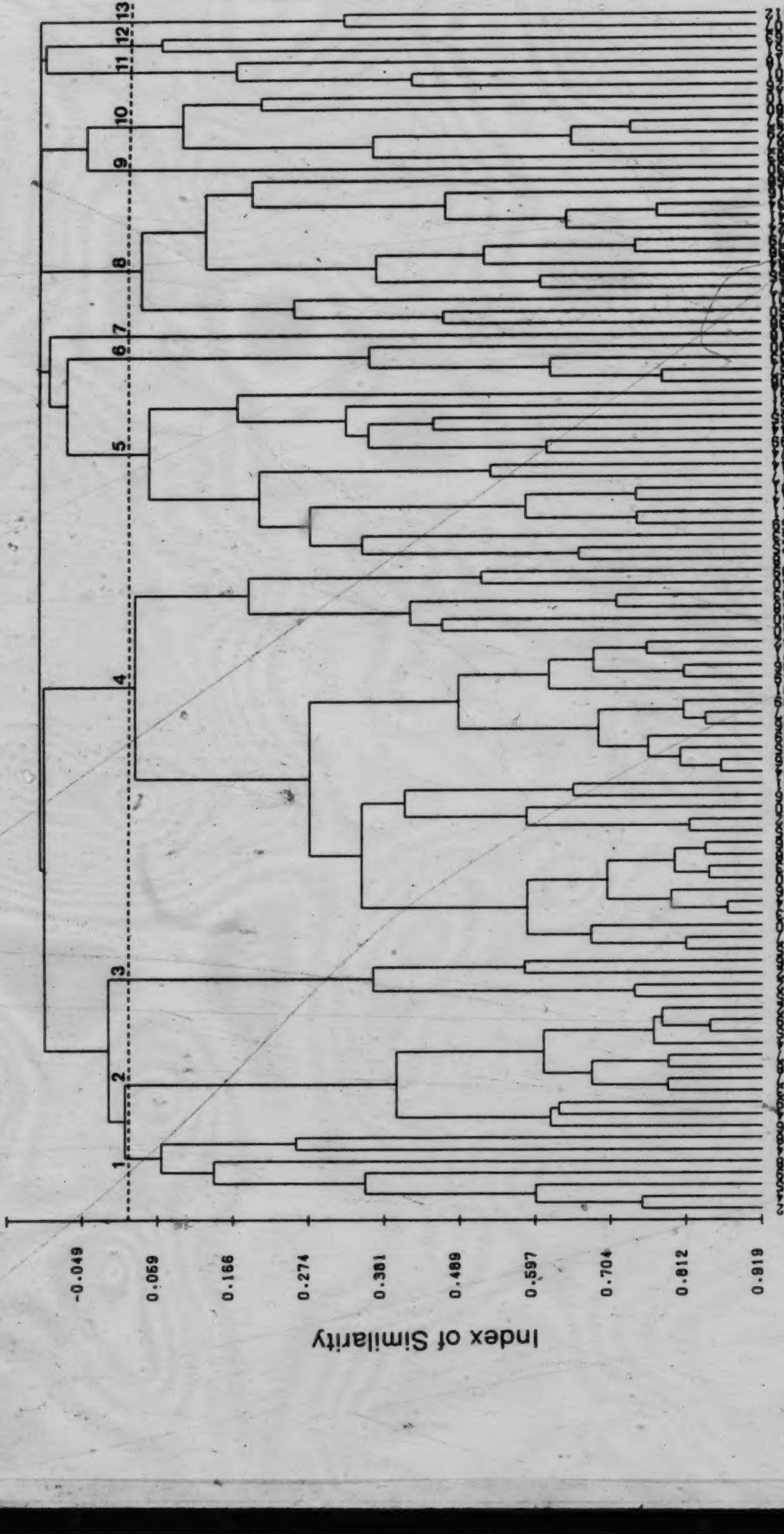


Figure 15: Complete-linkage cluster analysis of the 102 sites in the below treeline non-treed zone. Site numbers are along the bottom. The dashed line indicates the cluster cutoff point.

Cluster 9 consists of one poorly drained site, characterized by a high cover of *Cladina mitis* .

Cluster 10 (IS=.204) consists of 6 stands, characterized by a high cover of *Sphagnum* sp. .

Cluster 11 (IS=.281), consisting of three stands is dominated by *Festuca altaica* , and is most similar to Clusters 12 and 13.

Cluster 12 (IS=.174) consists of two stands dominated by *Arctagrostis latifolia* .

Cluster 13 (IS=.434) consists of two species-poor stands dominated by *Carex rostrata* .

6.3 Community Types

6.3.1 Betula glandulosa/Pleurozium schreberi CT

Cl# 2, IS=.507, n=11:16,54,203,204,238,339,347,349,447,462

This is a commonly occurring, stable, mesic-to-submesic community found predominantly on glacio-fluvial or morainal materials situated in valley bottoms. Elevation ranges from 840-1470 m. Soils are predominantly moderate to rapidly pervious, well drained Dystric Brunisols and Orthic Humo-Ferric Podzols. The pH of the rooting zone is extremely to strongly acidic (3.6-5.2)

This community is characterized by a well-developed MS stratum consisting almost exclusively of *Betula glandulosa* , and a well-developed bryoid mat. *Pleurozium schreberi* is the dominant bryophyte (25-60%) cover. *Polytrichum juniperinum* is almost always present, often with a high cover value. *Ledum palustre* and *Vaccinium uliginosum* are occasionally present in the LS stratum, with *Empetrum nigrum* being the common prostrate shrub. Forbs are rare, with *Cornus canadensis* occurring most often, but in trace amounts. *Festuca altaica* is the common graminoid which, if present, has a low cover value. There is a rich lichen flora with *Cladina stellaris* being most common, followed by *Stereocaulon* sp. , *Cladina rangiferina* , and trace amounts of *Cetraria nivalis, C. islandica*, and *C. cucullata.* Numerous Cladoniae lichens are present. While lichens are numerous, the cover of the bryophytes is usually higher.

6.3.2 Betula glandulosa/Hylocomium splendens CT

CI# 1. IS=.247. n=5:2,224,245,468,469

BEGL/HYSP is a submesic to mesic community occurring on well-drained Eluviated Dystric Brunisols and Orthic Humo-Ferric Podzols. formed on glaciofluvial materials. Elevation ranges from 835 to 1200 m.

This community is characterized by a well-developed MS stratum consisting exclusively of *Betula glandulosa* (20-50% cover). and a well-developed bryoid mat dominated by *Hylocomium splendens* (15-65% cover). *Polytrichum juniperinum* is always present (5-40% cover). and occasionally is the dominant bryophyte. Lichens constitute a significant component of the bryoid mat (4-25% cover. x=35%). *Cladina stellaris* is most common. though *C. mitis* or *C. rangiferina* is sometimes the dominant lichen. Trace amounts of *Cetraria nivalis* , *C. cucullata*, and *C. islandica* are often present. *Salix* sp. and *Vaccinium uliginosum* may be present in the low shrub strtum , with *V. vitis-idaea* being the common prostrate shrub. occurring prostrate shrub. Cover of these species is low. Forbs and grasses are rare. However. *Festuca altaica* and *Calamagrostis canadensis* may occasionally attain a cover of ca. 10%.

Plate 24. A well-drained E.DYB on a glacio-fluvial terrace. Site 2, BEGL/HYSP CT. Horizon order is as follows: L, 4 - 0 cm; 1C (Ash), 0 - 5 cm; Ae, 5 - 8 cm; Bm, 8 - 16 cm; BC, 16 - 33 cm; 2C, >33 cm.

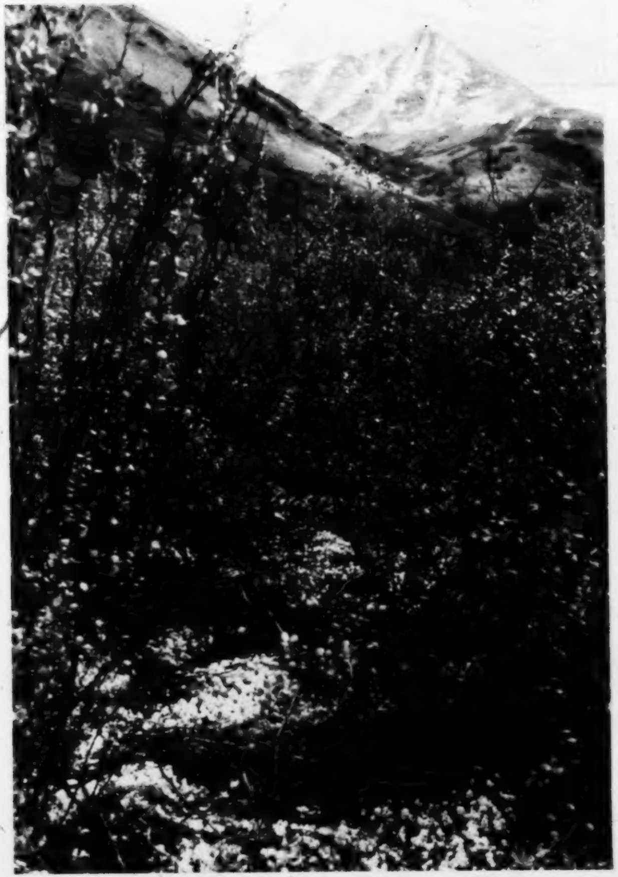


Plate 25. BEGL / HYSP CT, Site 2, (63° 06′ 50″ N, 130° 14′ 20″ W). Elevation - 1200 m. A mesic site dominated by *Betula glandulosa* (50% cover). The cover of *Cladina stellaris* is 45%, while *Hylocomium splendens* and *Polytrichum juniperinum* have 30% cover. Soil profile is shown in Plate 24. Date sampled - June 17, 1981.

6.3.3 Betula glandulosa/Cladina stellaris CT

Cl# 4, IS=.195, n=32:5,7,10,23,24,25,40,56,110,128,166,173,194 201,216,236, 249,250,266,269,271,289,331,342,348,386,389,427, 432,433,465

This a a commonly occurring mesic to submesic community found on sites very similar to those supporting BEGL/PLSC. Elevations range from 760 to 1250 M.

This community is very similar in species composition to BEGL/PLSC except that the crypotogamic mat is dominated by *Cladina stellaris* , which has a cover of 20-80%. Feather mosses occur often. *Polytrichum juniperinum* is present with 100% constancy. There may be numerous openings within this community where shrubs are absent.

Plate 26. BEGL/CLST CT, Site 24, 63° 17' 00" N, 130° 30' 00" W. Elevation - 1170 m. Site is dominated by *Cladina stellaris* (60% cover), and *Betula glandulosa* (35% cover). *Cladina rangiferina* and *Stereocaulon* sp. each have 10% cover. *Polytrichum juniperinum* has 20% cover. Eight other species are present in trace amounts. Date sampled - June 18, 1981.

6.3.4 Betula glandulosa/Polytrichum juniperinum CT

CI# 3, IS=.474, n=4: 155,302,362,486

This a subhygric to mesic community found on a variety of moderately well-drained soils formed on alluviual or morainal material. Elevation is from 915 to 1250 m.

This community is differentiated from the previous BEGL communities by the dominance of *Polytrichum juniperinum* (40-60%) and the almost complete absence of *Cladina stellaris* . *Sphagnum* sp. and associated species may be present. Ericaceous shrubs are common. *Rumex arcticus* , *Aconitum delphinifolium* and *Anemone parviflora* are occasionally present in trace amounts.

6.3.5 Salix sp./Graminoid/Sphagnum sp. CT

CI# 5, IS=.156, n=13:8,59,214,217,225,244,311,344,353,365, 391,431,461

This is typically a hygric to subhygric fen community situated on level to moderately sloping seepage sites, between 850 and 1350 m. Soils are typically slowly to moderately pervious, very poorly to imperfectly drained Gleysols occurring on alluvial or lacustrine parent material, or Organic soils occurring on organic parent material. Water was found in 9 of 13 soil profiles at depths of 1 to 70 cm. Frost was found in two profiles at depths of 60-70 cm.

This a rather loose community characterized by a high cover of *Salix* sp. (25-80%) in the MS or LS strata. *Betula glandulosa* and *Vaccinium uliginosum* occasionally occur. A herb stratum, dominated by graminoids, is most often present, with *Carex aquatilis* being most prominent with a mean cover of 31% and a constancy of 50%. *Calamagrostis canadensis, Carex canescens,* and *Festuca altaica* occasionally replace *Carex aquatilis* . *Sphagnum* sp. is the most common bryophyte, with 90% constancy, and a mean cover of 30%. *Aulacomnium palustre* is also very common. Cladinae and Cetraroid lichens are absent. *Peltigera aphthosa* and *Peltigera canina* often occur but with trace cover values. There is not a high diversity of forbs. The most common are *Epilobium angustifolium* , *Potentilla palustre* , and *Rumex arcticus* .

Plate 27. SASP / GRAM / SPH CT. Site No. 225, (63° 01′ 20″ N, 131° 52′ 90″ W). Elevation - 1140 m. A hygric community dominated by MS *Salix* sp. (40% cover), and *Sphagnum* sp.. Total graminoid cover is 25%. Six species of forbs are present with *Potentilla palustre* having the greatest cover (5%). Date sampled - July 16, 1981.

6.3.6 Salix sp./Carex aquatilis CT

CI# 8, IS=.226, n=12:38,117,124,141,165,234,260,284,316,358,438,479

This is a hygric to subhygric fen community occurring on level valley floors, between 850 and 1470 m. Soils are poorly to very poorly-drained, moderately to slowly pervious Gleysols, formed on alluvial plains, and Organic soils formed on organic parent materials. Water was present in all soil profiles, occurring from a depth of 60 cm to free standing surface water. Frost was not present. The pH of the rooting zone ranged from very strongly to moderately acidic (4.8-5.8).

This community is characterized by a high cover of *Carex aquatilis* (30-80%). MS *Salix* sp. is common, having a mean cover of 25% and a constancy of 85%. *Aulacomnium palustre* is the dominant bryophyte, with a constancy of 75%, and a mean cover of 18%. Leafy liverworts and *Mnium* sp. are common. *Sphagnum* sp. occurs occasionally. Forb species are numerous, with *Aconitum delphinifolium* , *Rumex arcticus* , *Potentilla palustre* and *Senecio triangularis* being the most common, though none have greater than 50% constancy, and all have low cover values.

Plate 28. SASP/CAAQ CT, Site 38, SW of Keele Peak, along a creek. (63° 13' 80" N, 130° 46' 80" W). Elevation - 1350 m. This site is dominated by MS *Salix* sp. (25% cover) and GS *Salix reticulata* (25% cover). *Carex aquatilis* is the dominant graminoid (30% cover) and *Tomenthypnum nitens* is the dominant bryophtye (40% cover). The soil is a Cumulic Humisol. Water was present at the surface. Date sampled - June 21, 1981.

6.3.7 Carex aquatilis / Sphagnum sp. CT

Cl# 10, IS=.207, n=5: 183,267,329,410,437

This a a hygric fen community found on level valley floors between 1000 and 1300 meters. Soils are typically moderately to slowly pervious, very poorly-drained Mesisols and Fibrisols formed on organic blankets. Rego Gleysols also occur on alluvial plains. Water was found in 3 of the 4 soil profiles at depths of 1 - 15 cm. pH of the rooting zone ranges from very strongly to moderately acidic (4.7 - 5.9).

This community is characterized by a high cover of *Sphagnum* sp. (30-90%) and *Carex aquatilis* (10-30%). The MS stratum is represented by either *Betula glandulosa* , which is most common, or *Salix* sp. . *Aulacomnium palustre* is common with a constancy of 80%, and a mean cover of 14%. Lichens are rare or absent. The GS stratum is represented by *Oxycoccus microcarpus* , which is always present but in trace amounts, and *Vaccinium uliginosum* which has a constancy of 80% but low cover values.

Plate 29. CAAQ / SPH CT, site 329, occurring on a very poorly drained organic veneer, overlying a silty-clay parent material. Elevation - 1035 m. This community is dominated by *Carex aquatilis* (35% cover) and *Sphagnum* (80% cover). 62° 51' 30" N, 130° 00' 40". Date sampled - July 28, 1981.

Table 21. Site data for four sites in each of the four BEGL-dominated CT's in the non-treed below treeline zone in Macmillan Pass. Species cover data are in Table 22. A '*' indicates that a photo of the site is included in the text.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth to Water	Depth to Frost	Soil Subgroup	Terrain Type
BEGL/CLST CT											
25.	1170.	N	2.	VF	R	SX	R	-.	-.	EDYB	PS-G.B
40.	1100.	N	2.	VF	M	M	W	-.	44.	OSC	-M.M
166.	1000.	L	0.	VF	M	M	W	-.	-.	OHFP	BS-M.B
331.	1100.	N	14.	LS	M	SM	W	-.	-.	OEB	-R.M
BEGL/PLSC CT											
54.	1305.	S	34.	MS	R	M	W	-.	-.	ODYB	GK-C.B
339.	840.	S	2.	VF	M	M	W	-.	-.	EDYB	GS-G.B
347.	1000.	L	0.	VF	R	M	VR	-.	-.	OHFP	GS-G.B
447.	1430.	SE	5.	MS	M	M	MW	-.	-.	EDYB	GS-M.B
BEGL/HYSP CT											
2.*	1210.	W	5.	VF	R	M	W	-.	-.	EDYB	GS-G.T
224.	1145.	L	0.	VF	M	M	MI	-.	-.	EDYB	GK-G.V
245.	915.	S	0.	VF	M	M	MI	-.	-		
468.	835.	W	18.	LS	R	SM	R	-.	-.	EDYB	S -G.P
BEGL/POJU CT											
155.	1250.	L	0.	VF	M	SH	MW	-.	-.	OR	-A.F
302.	1090.	L	0.	VF	M	M	MW	-.	-.	OG	C -A.P
362.	915.	L	0.	VF	S	SH	I	-.	-.	EDYB	S -M.M
486.	970.	S	18.	LS	R	SX	R	-.	-.		S -G.H

Table 22. Estimated % cover of plant speceis in four sites in each of four BEGL-dominated communities recognized in the Macmillan Pass/Sheldon Lake region. A '+' indicates occurrence in trace amounts, a '--' indicates species absence. Site data are in Table 21.

	BEGL CT's and site numbers-- Non-forested below treeline zone															
	Begl/Clst				Begl/Plsc				Begl/Hysp				Begl/Poju			
Species	25	40	166	331	54	339	347	447	2	224	245	468	155	302	362	486
Trees																
Abies lasiocarpa	--	--	2	--	--	+	[illegible]	--	--	--	--	--	--	--	--	--
Picea glauca	--	--	--	3	--	2	--	--	--	1	--	+	--	--	4	5
Picea mariana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--
Erect Shrubs																
Betula glandulosa	5	41	37	20	67	36	22	40	68	17	40	30	45	29	26	11
Ledum palustre	1	--	2	20	2	--	--	--	--	7	--	1	20	--	10	8
Vaccinium uliginosum	+	--	--	3	10	--	--	--	--	7	--	10	1	2	6	5
Salix sp.	--	4	--	--	--	--	--	--	+	--	2	--	--	27	--	17
Rosa acicularis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
Prostrate Shrubs																
Empetrum nigrum	--	--	--	+	35	--	--	3	+	4	--	--	10	--	2	--
Vaccinium vitis-idaea	+	--	+	5	3	1	+	2	+	2	+	1	+	--	3	3
Linnaea borealis	--	--	--	--	2	--	--	--	--	--	--	--	+	--	3	3
Arctostaphylos uva-ursi	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--
Forbs																
Cornus canadensis	--	--	--	--	5	--	--	5	--	--	--	--	--	--	--	10
Rubus chamaemourus	--	--	--	--	--	--	--	+	--	--	--	--	--	--	--	--
Campanula stellaris	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	2
Epilobium angustifolium	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	2
Lupinus arcticus	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	2
Aconitum delphinifolium	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--
Anemone parviflora	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--
Geocaulon lividum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+
Polemonium acutiflorum	--	--	--	--	--	--	--	--	--	--	--	--	--	+	--	--
Pyrola secunda	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	+

Table 22 continued.

	BEGL CT's and site numbers-- Non-forested below treeline zone															
	Begl/Clst				Begl/Plsc				Begl/Hysp				Begl/Poju			
Species	25	40	166	331	54	339	347	447	2	224	245	468	155	302	362	486
Graminoids																
Carex podocarpa	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--
Festuca altaica	1	--	--	--	--	--	5	--	+	--	--	20	3	5	--	+
Arctagrostis latifolia	--	--	--	--	--	--	--	--	--	--	+	--	--	--	--	+
Calamagrostis canadensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--
Carex sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	10	--	--
Pteridophytes																
Equisetum sylvaticum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--
Bryophytes																
Aulacomnium palustre	--	2	--	--	+	--	--	--	--	--	--	--	--	--	1	--
Dicranum sp.	--	--	--	2	--	5	--	2	--	--	--	--	5	5	--	2
Polytrichum juniperinum	20	4	65	40	20	20	35	30	30	10	40	5	50	60	45	40
Polytrichum commune	--	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleurozium schreberi	--	--	15	--	55	50	55	48	+	15	--	1	30	10	25	--
Hylocomium splendens	+	20	--	--	--	--	--	--	32	--	45	15	--	10	--	--
Sphagnum sp.	--	--	--	--	--	--	--	--	--	--	--	5	--	8	--	
Leafy Liverworts	--	--	--	--	--	--	+	+	--	--	--	--	--	3	--	--
Lichens																
Cladina stellaris	70	35	50	50	15	30	1	18	45	40	10	--	--	2	10	--
Cladina rangiferina	10	10	10	2	--	5	10	--	3	3	15	--	--	+	+	--
Cladina mitis	--	1	2	5	--	5	10	3	--	2	2	2	--	2	1	--
Cladonia sp.	+	1	1	1	+	3	1	3	+	1	+	4	--	1	+	+
Cetraria cucullata	--	5	+	+	--	--	+	--	--	1	1	--	--	--	--	--
Cetraria nivalis	+	1	1	+	--	2	--	--	--	--	--	--	--	--	+	--
Cetraria islandica	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--
Cetraria richardsonii	--	--	--	+	--	--	--	--	--	--	--	--	--	--	--	--
Stereocaulon sp.	10	2	10	30	--	2	--	1	3	--	--	--	--	--	--	--
Nephroma arcticum	--	1	+	--	--	--	--	--	1	2	+	--	--	+	2	--
Peltigera aphthosa	--	1	--	--	--	--	5	--	--	--	--	55	--	--	--	--

Table 23. Site data for four stands in each of the three fen CT's recognized in the Macmillan Pass study area. Plant species cover data are in Table 24. A '*' indicates that a site photo is included in the text.

Site	Elev	Aspect	% Slope	Site Position	Soil Pervious	Eco-Moisture	Soil Drainage	Depth to Water	Depth to Frost	Soil Subgroup	Terrain Type
SASP/GRAM/SPH CT											
8.	845.	L	0.	VF	M	SD	P	7.	-.	RG	C -L.P
225.*	1140.	L	0.	VF	M	HG		-.	-.		
344.	1165.	E	8.	VF	M	HG	P	40.	-.	RG	GS-M.B
461.	920.	L	0.	VF	S	H	VP	1.	-.	CUF	E -0.B
SASP/CAAQ CT											
38.*	1350.	S	0.	VF	M	SD	P	1.	-.	CUH	H -0.B
260.	1340.	L	0.	VF	M	HG	VP	15.	-.	M	-0.B
358.	1445.	L	0.	VF	M	HG	P	20.	-.	TYM	-0.B
438.	1465.	L	0.	VF	S	SD	VP	1.	-.	RG	C -L.P
CAAQ/SPH CT											
183.	1130.	L	0.	VF	S	HG	P	-.	-.		
267.	1035.	L	0.	VF	S	HG	P	-.	-.	TM	-0.V
329.*	1035.	L	0.	VF	R	HG	VP	-.	-.	TF	E -0.V
437.	1310.	L	0.	VF	S	HG	VP	-.	-.	RG	$ -A.P

Table 24. Estimated % cover of plant species in four stands in each of the three fen community types recognized in the Macmillan Pass/Sheldon Lake region. A '+' indicates occurrence in trace amounts, a '--' indicates species absence. Site data are presented in Table 23.

	Fen community type and site number											
	Sasp/Gram/Sph				Sasp/Caaq				Caaq/Sph			
Species	8	225	344	461	38	260	358	438	183	267	329	437
Trees												
Picea glauca	+	--	--	--	--	--	--	--	--	--	--	--
Abies lasiocarpa	--	--	--	--	--	1	--	--	--	--	--	--
Picea mariana	--	--	--	--	--	--	--	--	--	1	--	--
Erect Shrubs												
Salix sp.	68	43	45	45	32	5	29	30	--	31	2	--
Betula glandulosa	13	--	--	--	--	19	--	--	7	32	11	25
Vaccinium uliginosum	10	--	--	--	--	--	--	--	3	+	1	1
Kalmia polifolia	--	--	--	--	--	+	--	--	--	--	+	--
Ledum palustre	--	--	--	--	--	--	--	--	--	--	--	2
Prostrate Shrubs												
Arctostaphyles rubra	--	--	1	--	--	--	--	--	--	--	--	--
Salix reticulata	--	--	--	--	25	--	27	--	--	--	--	--
Empetrum nigrum	--	--	--	--	--	--	--	--	--	--	--	+
Oxycoccus microcarpus	--	--	--	--	--	--	--	--	+	+	+	+
Vaccinium vitis-idaea	--	--	--	--	--	--	--	--	--	--	--	+
Forbs												
Aconitum delphinifolium	--	--	+	--	--	--	1	--	--	--	--	--
Delphinium brachycentrum	--	--	1	--	--	--	--	--	--	--	--	--
Epilobium angustifolium	--	1	+	--	+	--	--	--	--	--	--	--
Mertensia paniculata	--	--	1	--	+	--	2	--	--	--	--	--
Rubus arcticus	+	1	1	--	1	+	2	--	--	--	--	--
Rubus chamaemourus	+	--	--	--	--	+	--	--	--	--	--	+
Rumex arcticus	--	2	1	--	--	--	--	--	--	--	--	--
Senecia sp.	--	--	5	--	--	--	--	--	--	--	--	--
Senecio triangularis	--	--	+	--	--	1	8	--	--	--	--	--
Viola episila	--	+	+	--	--	--	--	--	--	--	--	+
Parnassia montanesis	--	--	--	--	--	--	+	--	--	--	--	--

Table 24 continued.

Species	Fen community type and site number											
	Sasp/Gram/Sph				Sasp/Caaq				Caaq/Sph			
	8	225	344	461	38	260	358	438	183	267	329	437
Polemonium acutiflorum	--	--	--	--	+	--	5	--	--	--	--	--
Potentilla palustre	--	5	--	10	--	+	--	3	--	10	1	1
Sedum rosea	--	--	--	--	--	--	1	--	--	--	--	--
Veronica wormskjoldii	--	--	--	--	--	+	--	--	--	--	--	--
Pyrola asarifolia	--	--	--	--	--	--	--	--	--	--	+	--
Graminoids												
Arctagrostis latifolia	--	--	5	--	--	--	--	--	--	--	--	--
Carex rostrata	--	--	--	30	--	--	--	--	--	--	--	--
Grass species	--	10	--	--	--	--	--	--	--	--	--	--
Calamagrostis canadensis	30	--	--	--	--	--	--	--	--	--	--	--
Carex aquatilis	--	--	--	--	30	30	40	50	10	25	35	30
Eriophorum sp.	--	--	--	--	--	--	--	--	--	--	--	5
Festuca altaica	--	--	--	--	--	--	--	--	--	--	--	10
Pteridophytes												
Equisetum pratense	--	--	+	--	--	--	--	--	--	--	--	--
Equisetum sylvaticum	1	--	--	--	--	--	--	--	--	--	--	--
Bryophytes												
Aulacomnium palustre	15	20	10	--	5	--	10	30	--	5	5	1
Drepanocladus sp.	--	--	1	--	--	--	--	--	--	1	--	--
Hylocomium splendens	--	--	25	--	--	--	--	--	--	--	--	--
Pleurozium schreberi	--	--	--	--	--	2	--	--	--	--	--	20
Sphagnum sp.	60	60	10	10	--	5	+	--	90	60	80	60
Tomenthypnum nitens	--	--	5	--	40	35	--	--	--	--	--	--
Dicranum sp.	--	--	--	--	--	5	--	--	--	--	--	--
Helodium blandowii	--	--	--	--	--	--	35	--	--	--	--	--
Mnium sp.	2	--	1	--	2	1	15	--	10	1	--	--
Leafy Liverworts	+	--	2	--	--	2	10	10	--	3	--	+
Hylocomium splendens	--	--	--	--	--	5	--	--	--	--	--	--
Polytrichum juniperinum	--	--	--	--	2	5	--	--	--	--	1	+

6.3.8 Salix sp./Forb TCT

Cl# 5, IS=.721, n=2:74,199

This is an uncommon community which occurs in drainage channels on steep south- and west-facing slopes. Soils are imperfectly drained Eluviated Eutric Brunisols and Orthic Regosols formed on alluvial veneers. The pH of the rooting zone is slightly less acidic than is normal, ranging from very strongly to moderately acidic (5.2-5.9). Water is present in the soil profile at a depth of 60-70 cm.; frost was found in one profile at a depth of 70 cm.

This community is characterized by a dense TS stratum composed entirely of *Salix* sp. , and by a well-develped LS and herb stratum. Two LS species present, which rarely occur elsewhere are *Ribes triste* and *Rosa acicularis* . Common herbs are *Mertensia paniculata* , *Solidago multiradiata* , *Epilobium angustifolium* , and *Cornus canadensis* . *Calamagrostis canadensis* is always present.

Plate 30. SASP/FORB TCT, Site 74, (63° 27′ 30″ N, 131° 23′ 70″ W). Elev. - 1100 m. SW of Emerald Lake, in a steep S-facing drainage channel. It is dominated by *Salix* sp. (60% cover). Other shrubs are *Ribes triste* , *Rosa acicularis* , and *Rubus idaeus* . Soil - E.DYB formed on alluvium. Date sampled - June 27, 1981.

6.3.9 Salix sp./Hylocomium splendens TCT

CI# 6, IS=.726, n=3:208,383,467

SASP/HYSP is a hygric to mesic fen community occurring on level valley floors from 890 to 1400 m. Soils are imperfectly to poorly-drained Gleysols. The pH of the rooting zone ranges from very strongly to strongly acidic (4.9-5.2). Water is often found in the soil profile.

This community is characterized by a well-developed MS or TS stratum, dominated by *Salix* sp. , and an almost continuous bryoid mat, dominated by *Hylocomium splendens* . In addition, there is a relatively well-developed rich herb stratum with *Carex aquatilis* , *Calamagrostis canadensis* , *Mertensia paniculata* , *Festuca altaica* , *Senecio triangularis* , *Rubus chamaemorus* , and *Epilobium angustifolium* being some of the more common species. Other bryophytes which may be present are *Aulacomnium palustre* , *Sphagnum* sp. , *Polytrichum juniperinum* , and leafy liverworts. Lichens are rare or absent.

6.3.10 Festuca altaica/Sphagnum sp. TCT

CI# 10, n=1:380

This is a rare bog community located in the Dragon Lake area. It occurs on a poorly-drained Cumulic Mesisol in an opening in a PIMA/SPH community.

It is characterized by the unusual combination of *Festuca altaica* and *Sphagnum,* both present with a cover of 25%. Other mosses which also occur are *Tomenthypnum nitens* , *Scorpidium scoirpioides* , *Pleurozium schreberi* , and *Aulacomnium palustre* . Occurring in the poorly-developed LS stratum, is *Chamaedaphne calyculata* , which is rare elsewhere in the study area. *Menyanthes trifoliata* is the dominant forb. Cladinae lichens are present but with a low cover value. Occasionally MS *Picea mariana* is present.

6.3.11 Festuca altaica/Forb TCT

CI# 11, IS=.281, n=3:226,301,418

This is a mesic, valley floor community occurring on moderately pervious, moderately well-drained Gleysols and Brunisols, formed on alluvial or glacio-fluvial material. It occurs over a narrow range of elevation, between 900 and 990 m.

Species within the community belong to three major growth forms: graminoid, forb, and bryophyte. *Festuca altaica* is the dominant grass (35-80%), though *Calamagrostis canadensis* may also be common. There is a rich diversity of forbs, though *Polemonium acutiflorum* is the only species with 100% constancy. *Rumex arcticus* , *Senecio triangularis* , and *Mertensia paniculata* are common. Bryophytes occur in all plots, but there is no characteristic species. This community is very similar floristically to the FEAL communities found in the subalpine zone.

6.3.12 Festuca altaica/Cladina stellaris TCT

Cl# 4, n=1:270

This is a rare, mesic community type, found at 1100 m on a level alluvial plain. The soil is a moderately-well drained Orthic Regosol.

This community is characterized by a rare combination of *Festuca altaica* (30%) and *Cladina stellaris* (70%). Numerous other Cladinae and Cladoniae lichens are present. Forbs are numerous, with *Aconitum delphinifolium* being most common (2% cover). While this community is clustered with BEGL/CLST it is physiognomically most similar to FEAL/FORB.

Plate 31. FEAL/CLST TCT, 62° 55′ N, 131° 13′ 50″ W. Elev. - 1090 m. Date sampled - July 21/81.

6.3.13 Festuca altaica/Hylocomium splendens TCT

Cl# 4, n=1:290

This is a rare community characterized by the high cover of *Festuca altaica* and *Hylocomium splendens* . The high cover of *Hylocomium splendens* causes this stand to be clustered with SASP/HYSP. However, it appears on sites similar to those occupied by FEAL/FORB, and, except for the *Hylocomium splendens* , has a very similar species composition.

6.3.14 Arctagrostis latifolia/Forb TCT

Cl# 12, IS=.174, n=2:351,363

This is a valley floor community occurring in the southeastern section of the study area in the Prevost and Ross River drainages. It occurs on moderately pervious, imperfectly to poorly-drained Gleysols formed on alluvial material. Water is present in the soil profiles at a depth of 3 - 30 cm.

This community is dominated by graminoids and forbs, and is very similar in species compostion to the FEAL/FORB community. However *Festuca altaica* is replaced by *Arctagrostis latifolia* and *Poa lanata* . The forb and bryophyte components are very similar. ARLA/FORB also differs from FEAL/FORB in that it occurs on more poorly-drained soils.

6.3.15 Carex rostrata TCT

Cl# 13, IS=.434, n=2:301,412

This is a low-elevation, valley floor community occurring in the Sheldon Lakes area. It is found on very poorly-drained Gleysols formed on alluvial material and Cumulic Fibrisols formed on organic materials. Water is present at the soil surface.

This is a species-poor community (x=6) dominated by *Carex rostrata* . Forbs are rare or absent. Mosses (*Mnium* sp. , *Calligeron giganteum*) may be present. *Salix* sp. and *Betula glandulosa* may be present in trace amounts.

Plate 32. CARO TCT, Site 307, Mt. Sheldon area, (62° 41′ 40″ N, 131° 08′ 00″). Elevation - 920 m. Only two species were recorded at this site, *Carex rostrata* (50% cover) and *Potentilla palustre* (1% cover). The soil type is a Rego Gleysol occurring on an alluvial plain. 20 cm of mesic peat overlay a gleyed C horizon. Date sampled - July 25, 1981.

6.3.16 Betula glandulosa/Carex rostrata TCT

Cl# 1, n=1:338

This is a rare, low-elevation, valley floor community very similar to the *Carex rostrata* community and occurring on similar sites. Species composition is very similar except BEGL/CARO has *Betula glandulosa* present with a cover of 30%. It is found in the southeastern portion of the study area, along a tributary of the Prevost River.

6.3.17 Alopecurus aequalis/Tomenthypnum nitens TCT

Cl# 8, n=1:401

This is a rare, subhydric fen community located in the Dragon Lake area. It occurred in a valley bottom on a poorly-drained organic soil. Water was present 5 cm below the surface.

This community is dominated by graminoids with *Alopecurus aequalis* having a cover of 40% and *Carex aquatilis* of 25%. *Tomenthypnum nitens* is the dominant moss with a cover of 25%. Sphagnum was present in trace amounts. LS were represented by a sparse cover of *Betula glandulosa* and *Andromeda polifolia* . Forbs were rare, and present in trace amounts.

6.3.18 Epilobium latifolium TCT

n=1, Cl# 7

This is a rare community found on recent alluvial plains along major streams. Soils are Cumulic Regosols.

The community is characterized by a diverse forb stratum dominated by *Epilobium latifolium* . Other forbs are *Epilobium angustifolium* , *Artemisia arcticum* , *Polygonum viviparum* , *Pyrola secunda* , and *Achillea borealis* . LS *Salix* sp. and *Betula glandulosa* are present in trace amounts. *Drepanocladus* sp. and *Polytrichum juniperinum* are the common mosses. Lichens are absent.

6.3.19 Ledum palustre/Cladina mitis TCT

n=1 Cl# 9

This is a rare bog community occurring within a mosaic of forest communities in the Hess River drainage. It was found on a poorly-drained Terric Fibric Organic Cryosol, with frost present at 90 cm.

It is characterized by an almost continuous bryoid mat dominated by *Cladina mitis* growing on the dry microsites provided by *Sphagnum* sp. and *Aulacomnium palustre* . There is a well-developed low shrub and herb stratum, dominated by *Ledum palustre* . Forbs are rare, with the exception of *Rubus chamaemourus* . Numerous species of Cladoniae lichens occur. *Picea mariana* occurs in trace amounts in the MS stratum.

6.4 DECORANA Ordination Results

The 102 stands plotted against the X and Y axes of the DECORANA ordination are shown in Figure 17. The X-axis, which accounts for 80% of the variation within the data represents a complex-gradient. (All correlations cited below are significant at a=.05, a * indicates significance at a=.01.) It is positively correlated with increasing soil (r=-.79*) and ecological moisture (r=-.84) classes. It is also positively correlated with elevation (r=.23), C (r=.65), N (r=.71*), C/N (r=.33), Ca (r=.68*), Mg (r=.65), and pH (r=.40).

The Y-axis, which accounts for 34% of the residual variation, or 7% of the total variation was negatively correlated with pH (r=-.28) (Fig. 16)

The third and fourth axes accounted for so little of the total variation that they were not examined.

When plotted as rectangles on the X-Y ordination field, the communities formed two distinct groups: the mesic to subxeric *Betula glandulosa* communities lying at the dry, nutrient-poor left end of the X-axis; and the mesic to subhygric willow and graminoid communities occurring at the poorly drained, nutrient-rich right end of the X-axis. Lying midway between these two major groups is the mesic FEAL/FORB community (Fig. 17).

Within the *Betula glandulosa* group there is little overlap between communities on the X-Y ordination field. BEGL/MOSS CT's lie further along the X-axis than the BEGL/CLST community suggesting that they occur on moister, more nutrient-rich sites. However, when the BEGL CT's are ordinated separately, there is no correlation between the axes and the environmental variables examined (Fig. 18). The X-axis accounts for 26% and the Y-axis accounts for 15% of the total variation in the data.

Within the subhygric group there is considerable overlap between the major communities, especially along the X-axis, suggesting that the nutrient, pH, and moisture requirements of the communities are similar. Along the Y-axis, SASP/HYSP is well separated from CAAQ/SPH, occurring at the opposite end of the Y-axis. Between these communities lie the SASP/CAAQ and SASP/GRAMINOID/SPH communities which overlap considerably along both axes.

When the hygric communites are ordinated separately the ecological relationships among them communities are clarified. (Fig. 19). The X-axis (SD=4.5) of DECORANA ordination accounts for 60% of the variation within these communities. It is a complex gradient, positively correlated with soil moisture (r=.44), C (r=.64*), N (r=.52*), C/N (r=.38*), Mg (r=.53*), Ca (r=.57), and % clay (r=.31). It is negatively correlated with elevation (r=-.35) and %sand (r=-.41).

The Y-axis accounts for 34% of the residual variation or 13% of the total variation in the data. It is a complex-gradient positively correlated with slope (r=.52*), and negatively correlated with drainage (r=-.44*), N (r=-.32), Mg (r=-.28) and elevation (r=.-42*).

It may be inferred that communities or stands lying near the origin will have a tendency to be more level, higher elevation sites than those lying at the far ends of the X or Y-axis. In addition, those lying at the top of the Y-axis will occur on steeper, more nutrient-poor, better-drained sites. The SASP/GRAMINOID/SPSP, SASP/CAAQ, and CAAQ/SPH communities again overlap along the X-axis, wherease the SASP/GRAMINOID/SPSP and CAAQ/SPH communities are separated along the Y-axis.

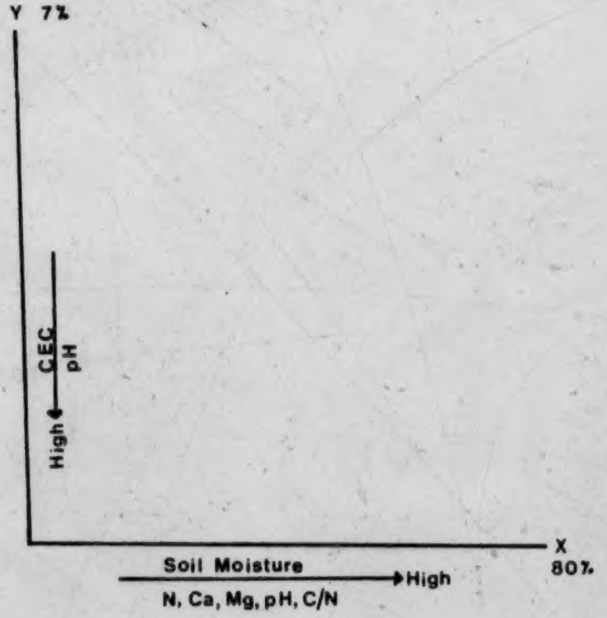


Figure 16. A diagramatic representation of the first two axes of the DECORANA ordination and correlated environmental variables. The X-axis accounts for 80% of the variation in the vegetation data.

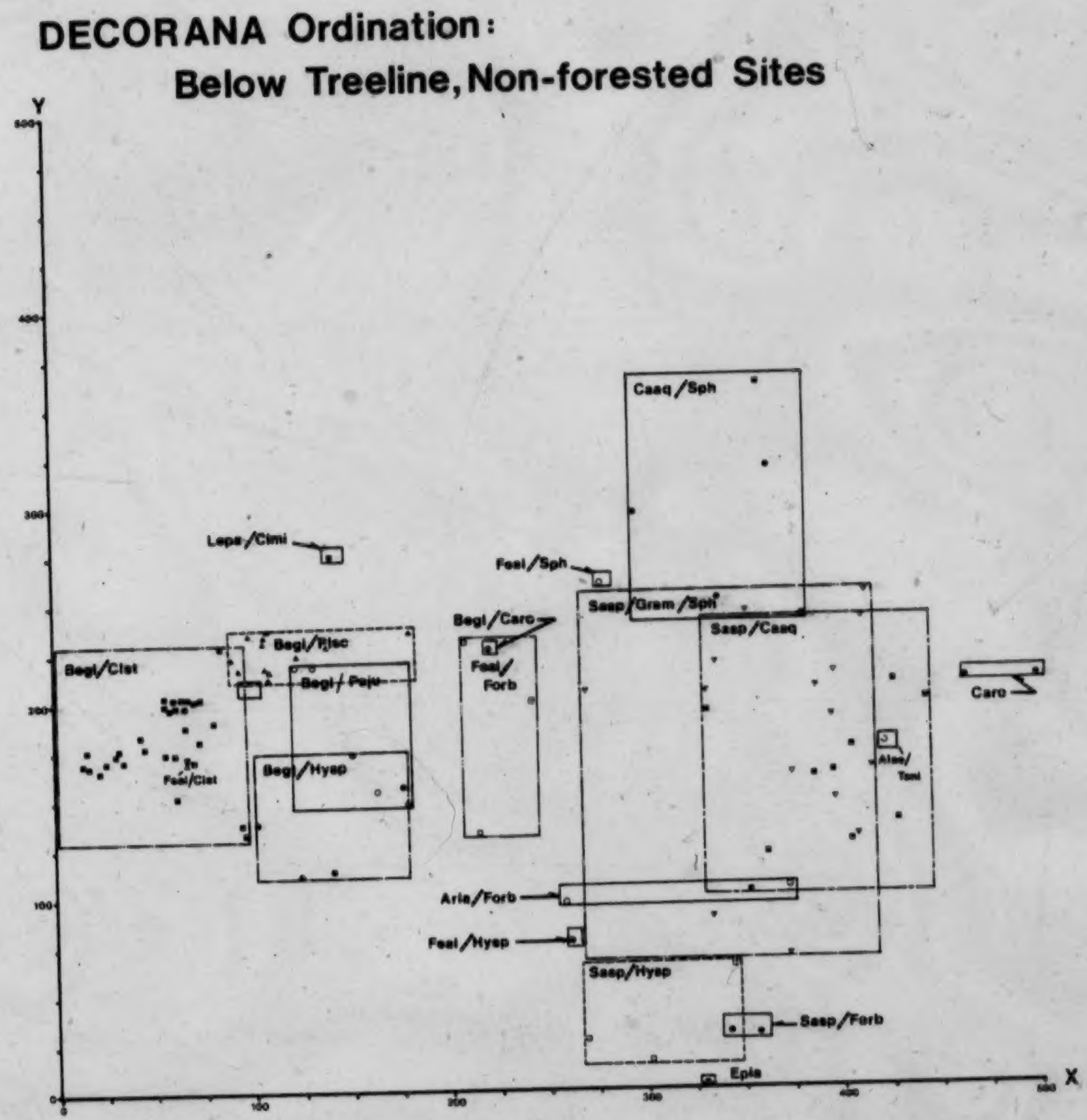


Figure 17. Location of the 102 below treeline, non-forested sites and the community types and tentative community types on the DECORANA ordination field. The submesic BEGL-dominated communites lie to the left; the fen communities to the right. The axes units are the average standard deviation of species turnover or S.D. Site coordinates on the axes are in Appendix VI.

DECORANA Ordination: Nontreed, Submesic Sites

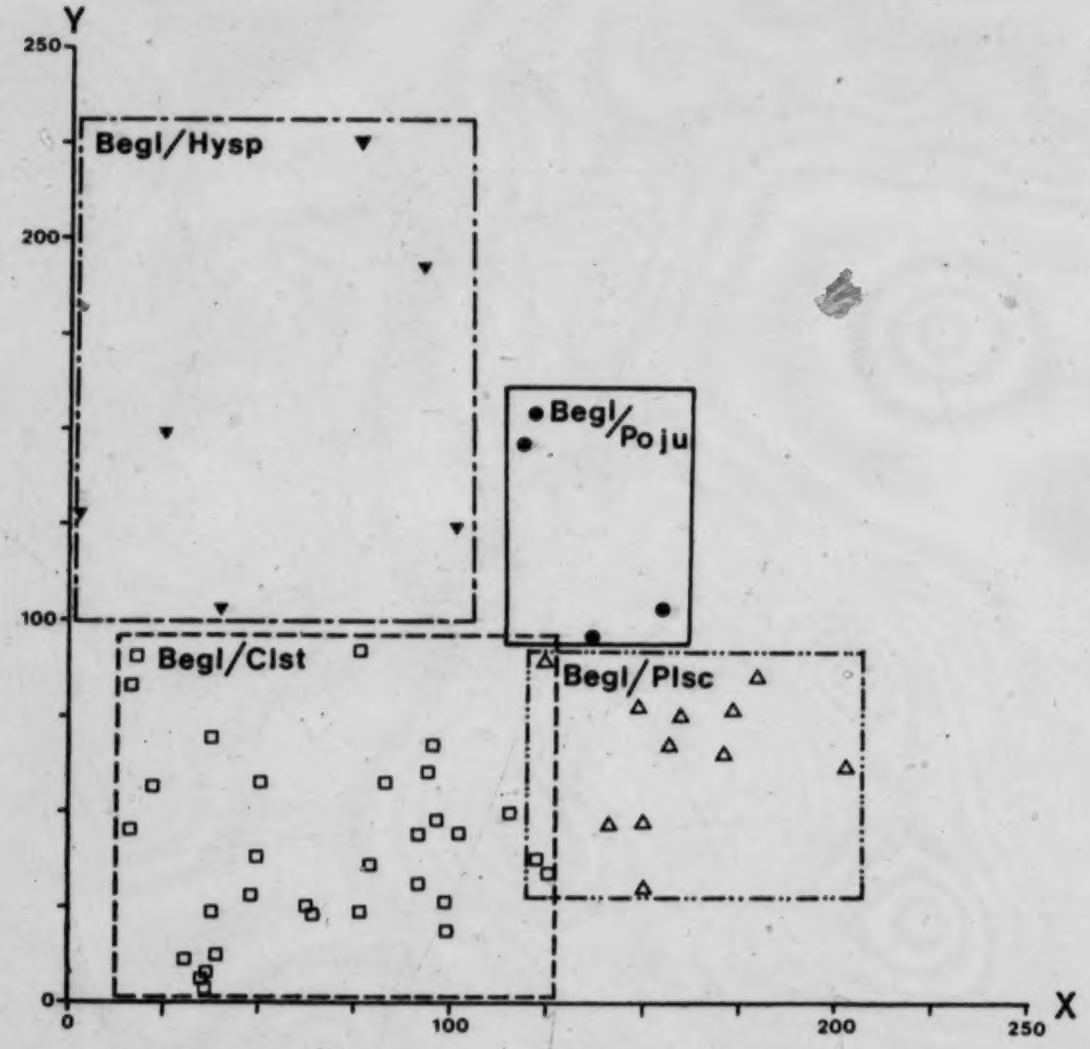


Figure 18. Location of the 52 BEGL-dominated sites and community types on the DECORANA ordination field. Site coordinates are in Appendix VI.

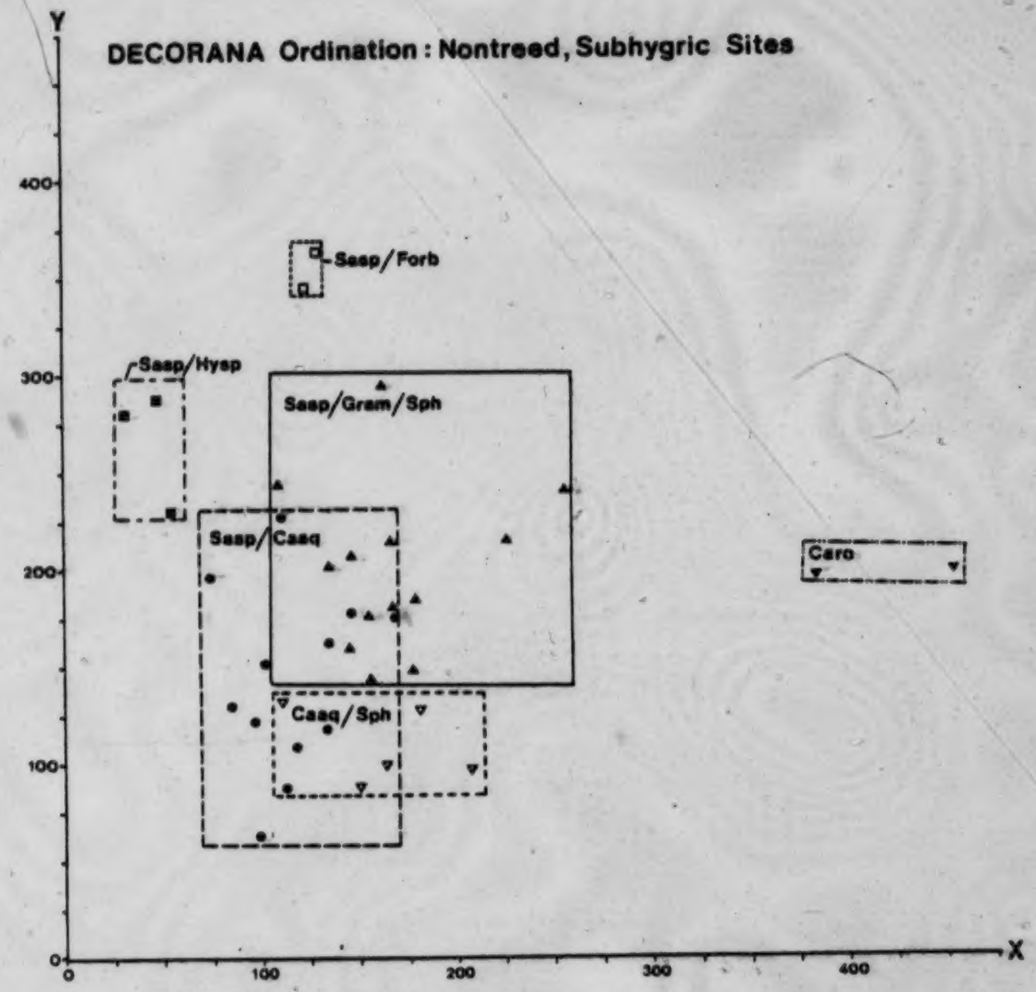


Figure 19. Location of the fen communities on the DECORANA ordination field. Site coordinates are in Appendix VI.

7. Keys to Vegetation Communities

Using the dichotomous keys given below, most of the vegetation of the Macmillan Pass/ Sheldon Lake area can be identified to community type. Eighty-five percent of the sites were placed in the correct community using the keys. Quantitative dominance of both physiognomic classes and species are the major criteria in the key.

1. Site has 10% or greater cover of tree species.	Key 7.1
1. Site has less than 10% trees or trees are absent.	2
2. Site is a recent burn that previously supported tree species, snags are present.	Key 7.1
2. Site occurs above the upper limit of trees.	Key 7.2
2. Site occurs below the upper limit of trees.	Key 7.3

7.1 Key to Forest Communities

1. Site a recent burn, recognizable by snags, fire scars, etc..	19
1. Site a treed stand,or an early primary successional stand.	2
2. Ground cover is dominated by prostrate shrubs, forbs, or grasses.	17
2. Ground cover is dominated by bryophytes or lichens.	3
3. Ground cover is dominated by lichens.	4
3. Ground cover is dominated by bryophtes.	7
4. Site an early successional river gravel bar, Decidious trees.	Poba/Sasp
4. Not as above.	5
5. Ground cover is dominated by *Stereocaulon* sp. or *Cladina mitis.*	26
5. Ground cover is dominated by *Cladina stellaris.*	6
6. *Sphagnum* with < 10% cover, if present.	Abla-Pima/Clst-ll
6. *Sphagnum* present with > 25% cover.	Pima/Plsc-Sph
7. Ground cover is dominated by *Polytrichum juniperinum, Aulacomnium* sp. occasionally co-dominant. *Empetrum nigrum* present, tree species is *Abies lasiocarpa.*	Abla/Emni/Poju
7. Ground cover dominated by Feathermosses +/or *Sphagnum +/or Dicranum.*	13
8. Ground cover dominated by *Hylocomiun splendens or Ptilium crista-castrensis.*	9
8. Ground cover dominated by *Pleurozium schreberii +/or Sphagnum +/or Dicranum.*	13

9. Ground cover dominated by *Ptilium crista-castrensis, Picea gluaca* is dominant tree species. Pigl/Ptcr
9. Ground cover dominated by *Hylocomiun splendens.* 10

10. *Pleurozium schreberi* has 25% or greater cover. Coni/Plsc
10. *P.schreberi has less than 25% cover.* 11

11. *Abies lasiocarpa* is the dominant tree species. Abla/Hysp
11. *Picea* sp. are the dominant tree species. 12

12. *Picea glauca* is the dominant species in the TT stratum. Pigl/Hysp
12. *P.mariana* is the dominant tree species, or *P.mariana/Abies lasiocarpa* are co-dominants. Pima/Hylo

13. Decidious tress are dominant in the tree stratum. Poba/Sasp
13. Conifers are dominant trees. 14

14. *Cladina stellaris* present with 30% or greater cover. Abla-Pima/Clst
14. *C. stellaris* absent or present with <20% cover. 15

15. *Abies lasiocarpa* is the dominant tree species, ground cover dominated by *Pleurozium schreberi*, or rarely *Dicranum sp., Picea* sp. are not present. Sphagnum, if present has < 10% cover. 29
15. *Picea sp. are the dominant trees.* 16

16. *Ground cover dominanted by Pleurozium shcreberi* and *Sphagnum*, which is usually associated with *Cladina stellaris.* 27
16. Ground cover is dominated by *Pleurozium schreberi* , *Sphagnum*, if present has a cover of <25%, and is not associated with *Cladina stellaris.* Coni/Plsc

17. Ground cover dominated by *Empetrum nigrum.* 28
17. Ground cover dominated by forbs or grasses. 18

18. Ground cover dominated by *Calamgrostis canadensis.* Pigl/Ptcr
18. Ground cover dominated by forbs, *Populus* sp. present. Pigl-Posp/Forb

19. Ground cover dominated by Bryophtes or Cladinae lichens. 20
19. Dominant ground cover is a mixture of forbs, grasses, or foliose lichens. 24

20. *Hylocomiun splendens* covers > 30% of the ground. Pima/Hysl
20. *H. splendens* has < 30% ground cover. 21

21. Cover of *Ledum palustre* is < 10%. Potr/Poju
21. Cover of L. palustre is greater than 10% 22

22. Cover of *Nephroma arcticum* is < 15%. Begl/Lepa/Poju
22. Cover of *N. arcticum is* > 15% cover Sasp-Begl/Emni

23. *Epilobium angustifolium* present(2-25%), *Festuca altaica* present(10-30%), both *Betula glandulosa* + *Salix* sp. are present. Begl-Sasp/Feal
23. Above condidtions not met. 24

24. Salix (TS or MS) present with > 15% cover.	Begl-Sasp / Forb
24. Salix present with less than 10% cover, *Ledum palustre* present with > 15% cover, *Peltigera apthosa* present with > 15% cover.	Lepa / Peap
25. *Abies lasiocarpa* is the dominant tree species.	Abla / Emni
25. *Picea mariana* is the dominant tree species, *Sphagnum is present.*	Pima / Clst
26. *The cover of Sphagnum* is greater than that of *Pleurozium schreberi*.	Pima / Sph-Clst
26. The cover of *Pleurozium schreberi*is greater than that of *Sphagnum*, or the two are co-dominant.	Pima / Plsc-Sph
27. *Abies lasiocarpa* is the dominant tree species.	Abla / Emni
27. *Picea mariana* is the dominant tree species.	Pima / Emni / Clst
28. *A.lasiocarpa* present with > 35% cover.	Abla / Plsc
28. *A. lasiocarpa* present with < 30% cover.	Coni / Plsc

7.2 Key to Communities Occurring Above Treeline

1. Area a recent burn, recognized by charred soil, exposed burn roots, etc.	Heal / Poju
1. Area not a recent burn	2
2. The dominant species is a moss or lichen	3
2. The dominant species is a vascular plant	27
3. Area dominaated by lichens	4
3. Area dominaated by bryophytes	12
4. *Cladina stellaris* is the dominant lichen	5
4. *Alectoria* sp. or *Stereocaulon* sp. is the dominant lichen	11
5. *Betula glandulosa* or *Cassiope tetragona* are the dominant shrubs	6
5. *Ericaceous* shrubs are the dominant shrubs	9
6. *Cassiope tetra gona* is the dominant shrub	Cate / Clst
6. *Betula glandulosa* is the dominant shrub	7
7. *Stereocaulon* sp. has greater than 20% cover	Begl / Clst / Stsp
7. *Stereocaulon* sp. if present has less than 20% cover	8
8. *Alectoria* sp. has greater than 10% cover	Clst / Aloc
8. *Hylocomiun splendens* has greater than 20% cover	Begl / Clst
9. *Alectoria* sp. present with greater than 10% cover	10
9. *Alectoria* sp. absent or present with less than 10% cover	Ericad / Aloc
10. *Stereocaulon* sp. present with greater than 30% cover	Begl / Stsp
10. *Stereocaulon* sp. if present has less than 25% cover	Clst / Aloc
11. *Stereocaulon* sp. is the dominant lichen	Begl / Stsp
11. *Alectoria ochroleuca* is the dominant species	Ericad / Aloc

12. Feather mosses are the dominant mosses	13
12. Mosses other than feather mosses are dominant	18
13. *Hylocomium splendens* is the dominant moss	14
13. *Pleurozium schreberi* is the dominant moss	16
14. Shrubs are the dominant vascular species	15
14. Forbs are the dominant vascular species	Vevi / Hysp
15. *Cassiope tetragona* is the dominant shrub	Cate / Hysp
15. *Betula glandulosa* and/or *Salix* sp. are the dominant shrubs	Sasp / Begl / Hysp
16. MS *Salix* sp. are present	17
16. Not as above, forbs are the dominant vascular species	Capo / Plsc
17. Fruticose lichens are present	Sasp / Plsc
17. *Carex aquatilis* is the dominant vascular species	Sasp / Caaq / Plsc
18. *Carex aquatilis* is the dominant vascular species	19
18. Shrubs, forbs, or grasses are the dominant vascular species	20
19. *Tomenhypnum nitens* is the dominant moss	Caaq / Moss
19. *Sphagna* are the dominant species	Caaq / Moss
20. *Aulacomium* sp. is the dominant moss	21
20. *Polytrichum* sp. or *Dicranum* sp. is the dominant moss	23
21. *Senecio triangularis* is the dominant species	Setr / Aupa
21. LS or GS dominate the vascular species	22
22. *Dryas integrifolia* and *Carex podacarpa* are present	Capo / Aupa
22. *Phylodoce empetriformis* and *Luzula parviflorus* are present	Lyal / Aupa
23. *Dicranum* sp. is the dominant bryophyte	24
23. *Polytrichum* sp. is the dominant bryophyte	25
24. *Alectoria* sp. is present with 10% or greater cover	Ericad / Aloc
24. *Alectoria* sp. is absent or if present has less than 10% cover	Cate / Pisp / Poju
25. *Cladina stellaris* present with +15% cover	26
25. *C. stellaris* absent or present with a low cover value, *Festuca* present	Feal / Poju
26. *Empetrum nigrum* present with +15% cover, *Festuca* absent	Emni / Poju
26. *E. nigrum*, if present, has a cover of 5% or less, *Festuca* present	Cate / Clst
27. Grasses or forbs are the dominant species	28
27. Shrubs are the dominant species	33
28. Grasses are the dominant species	29
28. Forbs are the dominant species, *Festuca altaica* present	Feal / Forb

29. *Calamagrostis canadensis* is the dominant grass	30
29. *Festuca altaica* is the dominant grass	31
30. Shrubs are rare or absent, forbs common	Caca / Hysp
30. *Vaccinium uliginosum* is common	Vaul / Caca
31. Forbs are common, shrubs are rare	Feal / Forb
31. *Betula glandulosa* or *Cassiope tetragona* are the dominant shrubs	32
32. *Cassiope tetragona* is the dominant shrub	Cate / Feal
32. *Betula glandulosa* is the dominant shrub	Sasp-Begl / Feal
33. *Ericaceous* shurbs are dominant	34
33. Other shrubs are dominant	41
34. *Ericaceous* shurbs excluding heathers are dominant	35
34. Heathers are dominant	36
35. *Arctostaphylus rubra* is common	Lyal / Aupa
35. *Vaccimum vitis-ideae* is common	Eric / Feal / Plsc
36. *Phyllodoce empetriformis* is the dominant shrub	Lyal / Ausp
36. *Cassiope tetragona* is the dominant shrub	37
37. *Festuca altaica* present with +10% cover	Cate / Feal
37. Not as above, mosses or lichens are common	38
38. Lichens are the dominant non vascular species	Cate / Clst
38. Mosses are the dominant non vascular species	39
39. *Polytrichum* sp. or *Aulacomnuim* sp. are dominant mosses	40
39. *Dicranum* sp. is the dorminant moss	Cate / Disp / Poju
40. *Dicranum* sp. is present with 20% or greater cover	Cate / Disp / Poju
40. *Dicranum* sp. is absent or present with less than 20% cover	Cate / Poju
41. *Dryas integrifolia* and *Salix reticulata* are the dominant shrubs	Drin / Sare
41. *Salix* sp. or *Betula glandulosa* are dominant shrubs	42
42. *Betula glandulosa* is the dominant shrub	43
42. *Salix* sp. is the dominant shrub	44
43. *Hylocomnium splendens* present with +20% cover	Sasp-Begl / Hysp
43. *H. splendens* not present	Begl / Stsp
44. *Hylocomnium splendens* present	Sasp-Begl / Hysp
44. *H. splendens* not present	Sasp / Feal

7.3 Key to Non-Forest Communities Below Treeline

1.	Site is a mesic to xeric site, dominated by *Betula glandulosa*, and a cryptogamic mat.	2
1.	Site not as above.	8
2.	A lichen has the highest cover in the cryptogramic mat.	3
2.	A bryophyte has the highest cover in the cryptogramic mat.	5
3.	A foliose lichen is the dominant lichen.	Begl/Hysp
3.	A fruticose lichen is the dominant lichen.	4
4.	*Cladina stellaris* is the dominant lichen.	Begl/Clst
4.	*Cladina mitis* is the dominant lichen.	Begl/Hysp
5.	*Polytrichum juniperinum* has the highest cover of the bryophytes.	6
5.	A feathermoss has the highest cover in the cryptogamic mat.	7
6.	*Cladina stellaris* is present with >30% cover.	Begl/Hysp
6.	*C. stellaris* is absent or rare.	Begl/Poju
7.	*Pleurozium schreberi* is the dominant moss, *C. stellaris* has <35% cover.	Begl/Plsc
7	*Hylocomiun splendens* is the dominant bryopyte.	Begl/Hysp
8.	*Salix* sp. and/or *Betula glandulosa* are conspicious, >20% cover.	9
8.	Not as above.	14
9.	*Betula glandulosa* is the dominant shrub.	10
9.	*Salix* sp.is the dominant shrub.	11
10.	*Carex rostrata is the dominant graminoid.*	Begl/Caro
10.	*C. aquatilis* is the dominant graminoid.	Sasp/Caaq
11.	A bryophyte has the highest cover value.	12
11.	A vascular species has the highest cover value.	13
12.	*Hylocomium splendens has the highest cover value.*	Sasp/Hysp
12.	*Sphagnum* has the highest cover value.	Sasp/Gram/Sph
12.	*Drepanocladus* sp. has the highest cover value.	Sasp/Gram/Sph
12.	*Tomenhypnum* sp. has the highest cover value.	Sasp/Caaq
13.	*C. aquatilis* is the dominant species,*Sphagnum* has <20% cover.	Sasp/Caaq
13.	C. aquatlis is the dominant species, *Sphagnum* present with >25% cover.	Sasp/Gram/Sph
14.	A vascular species has the highest cover value.	15
14.	*Cladina mitis* present with very high cover, *Ledum groenlandicum* dominant shrub.	23
15.	Forbs are dominant, *Epilobium latifolium* is common.	Epla
15.	Graminoids are dominant.	16

16. A grass species has the highest cover value.	17
16. A sedge has the highest cover value.	24
17. *Festuca altaica* is the dominant grass.	18
17. *Arctogrostis latifolia* has >10% cover, *Poa lanata* often present.	Arla / Forb
17. *Alopecerus aequalis* is the dominant grass.	Alae / Toni
18. Forbs are common.	Feal / Forb
18. Non-vascular species are common.	19
19. Bryophytes are present with a high cover.	20
19. Lichens are present with a high cover.	21
20. Sphagnum is present.	Caaq / Sph
20. *Hylocomium* is present.	Sasp / Hysp
21. *Cladina stellaris* is dominant lichen.	Feal / Clst
21. *C. mitis* is dominant lichen.	Feal / Forb
22. *Carex rostrata* is the dominant sedge.	Caro
22. *C. aquatilis* is the dominant sedge.	Sasp / Caaq
23. *Cladina mitis* present with a high cover value, Ledum is dominant shrub.	Lepa / Clmi
23. *Cladina stellaris* is present with >50% cover.	Begl / Clst

8. Discussion

8.1 Environmental Gradients

Most researchers recognize that vegetation patterns reflect several complex environmental gradients. This is shown by the DECORANA ordination results where each axis is correlated with several environmental factors. The factors that are most strongly correlated with the axes are considered to be the ones which have the greatest effect on species distribution. This approach in interpretation is complicated by the fact that variation in species composition is associated with many inter-related factors that cannot be considered independently. It is difficult to assess two factors (e.g. soil pH and Al) which are correlated with different perpendicular axes and infer that they are independent. In some instances the X and Y axes were correlated with each other. Therefore, the reader is cautioned to consider the relationships between species and community distribution and environmental factors discussed in this section and the preceeding Results as hypotheses requiring further testing, rather than as established cause-effect relationships.

8.1.1 Forest Communities

Elevation and moisture are perhaps the most frequent correlates of variation in mountain vegetation. Several other factors which may be locally significant include soil depth, soil texture, wind exposure, and snow related phenomena (Peet 1981). del Moral and Long (1977) found that air temperature, primarily as it affects snow depth, controls most variation in the mature forests of the western Washington Cascades. Patten (1963) stated that in the Madison Range, Montana, a high percentage of the variation in the vegetation was accounted for by a group of environmental factors, the most important being permanent wilting point and clay content of the soil, both of which have a direct influence on soil moisture. Eis (1962) found that soil moisture, groundwater and soil permeability combined accounted for 79% of the variation in plant communities located in the Vancouver, B.C area. Beese (1980) found that moisture availability had the highest correlation with species distribution on the east coast of Vancouver Island.

Within the boreal taiga zone, major environmental gradients are somewhat different from the mountain areas. The important environmental factors controlling vegetation community distribution in the taiga of central Alaska appear to be soil temperature, soil moisture and soil nutrient status. Forest sites extend over a wide environmental gradient, but can basically be divided into 1) cold, wet black spruce sites, with low nutrient availability, usually underlain by permafrost, and 2) warm, well-drained, mesic white spruce sites and their successional stages on permafrost-free soils (Viereck et.al. 1983, Yarie 1983).

Jeglum (1974) found that moisture-aeration and nutrient regimes explained a large portion of the variation in minor vegetation and tree growth on black spruce peatlands in the taiga of northern Ontario.

. The major environmental factors controlling vegetation within the forested zone of the study area appear to be neither elevation nor soil moisture. The X-axis of the DECORANA ordination, which represents the longest community gradient (3.3 SD) and accounts for 44% of the variation in the vegetation data, is highly correlated with soil pH and nutrients (N, Ca, Mg). Elevation, drainage, and depth to permafrost are most correlated with the shorter Y-axis (2.76 SD), which accounts for 21% of the variation in the vegetation data.

A number of workers have used single-factor measurements as correlated indicators or parameters of soil nutrient status and have described the distribution of vegetation along these gradients. The most widely used variables have been pH, electrical conductivity, calcium, potassium and nitrogen (Wali and Krajina 1973).

Pearsall (1952) regarded pH as the single most useful measurement that could be made for ecological purposes. Soil pH is important in determining plant distribution primarily as it affects nutrient availability (Brady 1974). Low pH results in increased solubility of certain heavy metals (e.g. Al, Mn, Fe, Zn) in the soil. Hydrogen ions and these metallic ions compete for soil cation exchange sites, displacing other essential cations, such as calcium and magnesium, which are subsequently leached from the soil (Bartuska and Ungar 1980).

Calcium, which is required for tree nutrition in small amounts (Heilman 1979), affects forest tree growth directly as a plant nutrient and indirectly by affecting soil reaction and other properties, particularity in ameliorating the effects of excessive amounts of Na, K, Mg, Al, Mn and others that may become toxic to plants (Wilde 1958, in

Wali and Krajina 1973). Calcium is by far the most widely used indicator of soil nutrient status (Wali and Krajina 1973).

Heilman (1979) considers nitrogen to be the most important of the soil-derived nutrients in forest soils of the Douglas-fir Region. Nitrogen in soils is mostly contained in the organic fraction, and must be converted to inorganic form by the actions of microorganisms, through the process of nitrogen mineralization, in order to be used by plants. Factors reducing N mineralization rates are cold soil temperatures, very high or low soil moisture contents, inadequate soil aeration and a high ratio of carbon to nitrogen (C:N ratio). High C:N ratios (i.e. above 25 - 30:1 in the mineral soil) indicate low availability of nitrogen to plants.

Exchangeable aluminum was correlated with the Y-axis of the DECORANA ordination of the forest sites. Multiple-range tests indicate that the Al of the B horizons was significantly higher in ABLA CT's than in the other forest communities (Table 16). Aluminum is not an essential plant nutrient, but may be toxic to plants in highly acidic soils. Most tree species appear to be tolerant of aluminum but research shows it may be toxic to the roots of some trees (Heilman 1979). Hoyle (1971) found that yellow birch root (*Betula alleghaniensis* Britton) is inhibited by Al in the lower substrates. However, the data indicated that the severity of Al toxicity varied with macronutrient deficiency. Bartuska and Ungar (1980) found that high levels of Al (5.35 meq/ 100 g) were not toxic to *Betula nigra*. In the present study exchangeable soil Al was highest in the ABLA/ HYSP CT (x=3.73±3.22). The naturally high levels of Al under the ABLA CT's could have important implications for revegetation of mountain slopes following mining activity.

The DECORANA ordination (Figs. 10 - 12) and multiple range-tests (Tables 15 - 18) suggest that 1) white spruce CT's occur on more neutral, nutrient-rich sites than black spruce and subalpine fir CT's, and 2) subalpine fir CT's occur on more acidic, nutrient-poor sites than black spruce CT's. It is generally held, however, that subalpine fir requires more nutrients than black spruce (Krajina 1979). The data presented in this thesis do not necessarily contradict this contention. Nutrients on the black spruce sites may not be available to the trees. Wali and Krajina (1973) found high levels of calcium under black spruce communities but stated that the black spruce sites had low base saturation, hence it is doubtful if all the calcium at these sites was readily available. The high soil moisture content and low soil temperatures of black spruce sites will reduce N mineralization, and therefore reduce the fraction of the total nitrogen that is available to plants.

It must be noted that the plant/soil relationships determined here are based exclusively on the mineral soil horizons. Kimmins and Hawkes (1978) found that 88% of the overstory fine root tips occurred in the forest floor (LFH horizon) and the Ae horizon. Weetman (1968) found that continuous feathermoss carpets which grow on a cumulative layer of raw humus had intense black spruce rooting at the base of the moss carpet where it was decomposing. He surmised that feathermosses probably represent one of the major sources of nitrogen for trees. Given the above, correlations between the ordination axes and the nutrients of the LFH may have produced different results.

A comparison of soil nutrient status between sites within this study and soils of other forests, especially those in British Columbia, did not reveal major differences (Table 25). However, it should be noted that soils are probably more developed in the southern areas, resulting in deeper horizons, and thus a larger nutrient pool.

It is interesting that the X-axis of the forest site ordination, which represents a gradient from PIMA/SPH CT's to PIGL/HYSP CT's, is not correlated with depth of permafrost or soil drainage. Viereck et.al. (1983) stated that in central Alaska white spruce is found on better drained, permafrost-free sites. This is not the situation in the present study where white spruce occurred on poorly drained, frozen soils (Table 19). Soil drainage and depth to permafrost were positively correlated with the Y-axis, which represents a gradient from PIMA/SPH CT's to ABLA/PLSC CT's. The PIMA and PIGL communities have considerable overlap along this gradient. It should be noted that the thickness of the active layer was recorded on differing dates throughout the summer: therefore thaw depths are only approximate as the active layer will not be as thick in early June as it would be in late August.

A notable result of the DECORANA ordination was the distribution of the burned sites on the ordination field. They did not occur as outliers, but lay within the boundaries of the communities to which, based on present species composition and site factors, they are likely to succeed to. Since there are vast tracts of burned land within the Yukon where the original community is not known, an ordination of burned and adjacent unburned sites could prove to be a useful tool in predicting successional trends and climax communities.

Table 25. Mean nutrient values of soils from selected communities compared with those of other areas.

Soil Horizon	No. of Samples	Exchangeable Mean meq/100 g			Total N (%)	C/N
		Ca	Mg	Al		
		[(s.d) in brackets]				
A Horizons						
1 Abla/Hysp	5	6.9 (6.4)	3.0 (2.8)	3.2 (4.7)	0.4 (2.3)	15 (2.9)
2 Abla/Plsc	3	0.3 (0.0)	0.05 (0.05)	5.7 (6.4)	1.6 (0.01)	16 (2.9)
3 Pigl/Hysp	4	25.0 (13.6)	4.6 (3.9)	--	0.9 (0.7)	12 (5.6)
4 Pima/Hysp	1	24.1	7.8	--	1.2	17
5 Conifer/Plsc	6	13.4 (14.9)	2.4 (2.2)	4.2 (6.4)	0.4 (0.4)	20 (6.4)
6 Abla-Pima/Clst	3	0.3 (0.05)	0.03 (0.5)	3.6 (1.9)	0.2 (0.06)	11 (5.1)
8 Abla-SW Yukon	2	1.3	0.5	--	0.4	18
11 SW B.C.	5	12.8	1.5	--	0.4	18
12 Douglas-fir	7	17.2	2.0	--	0.4	19
B Horizons						
1 Abla/Hysp	6	2.6 (3.4)	1.1 (1.4)	3.7 (3.2)	0.2 (0.1)	10 (3.1)
2 Abla/Plsc	4	0.4 (0.3)	0.05 (0.05)	3.6 (1.5)	0.2 (0.1)	13 (1.0)
3 Pigl/Hysp	5	6.4 (2.4)	1.9 (1.2)	1.2 (0.4)	0.2 (0.07)	14 (1.2)
4 Pima/Hysp	3	6.3 (8.3)	2.4 (3.8)	1.9 (0.9)	0.3 (0.2)	15 (1.2)
5 Conifer/Plsc	9	5.0 (5.1)	1.9 (2.6)	2.8 (1.4)	0.2 (0.1)	13 (4.3)
6 Abla-Pima/Clst	9	0.3 (0.2)	0.02 (0.07)	2.1 (1.3)	0.1 (0.03)	11 (5.9)
7 Pima/Plsc-Sph	5	1.2 (1.3)	0.6 (0.8)	3.0 (1.4)	0.2 (0.05)	11 (4.0)
8 Abla-SW Yukon	2	1.1	0.5	--		
11 SW B.C.	12	6.4	0.8	--	0.1	17
12 Douglas-fir	7	2.9	0.4	--	0.1	16

Table 25 continued.

Soil Horizon	No. of Samples	Exchangeable Mean meq/100 g Ca	 Mg [(s.d) in brackets]	 Al	Total N (%)	C/N
C Horizons						
1 Abla/Hysp	6	2.2 (2.1)	0.4 (0.4)	2.5 (1.6)	0.2 (0.2)	11 (3.2)
2 Abla/Plsc	2	0.3 (0.2)	0.05 (0.05)	0.7 (0.4)	0.7 (0.03)	9 (0.5)
3 Pigl/Hysp	10	14.0 (10.0)	3.2 (1.9)	--	0.3 (0.2)	16 (3.9)
4 Pima/Hysp	5	7.2 (2.1)	1.9 (0.6)	--	0.2 (0.2)	12 (2.9)
5 Conifer/Plsc	14	--	--	--	0.2 (0.2)	13 (4.6)
6 Abla-Pima/Clst	11	2.4 (3.3)	0.5 (0.8)	1.6 (0.8)	0.1 (0.1)	10 (4.1)
7 Pima/Plsc-Sph	5	2.4 (1.9)	0.6 (0.6)	1.4 (1.1)	0.1 (0.1)	11 (1.8)
8 Abla-SW Yukon	3	1.5	0.9	--	--	-
9 Ws/Fm-SW Yukon	6	5.9	0.7	--	--	-
10 Lodgepole pine - SW YT	6	2.8	0.9	--	--	
11 SW B.C.	6	5.2	0.5	--	0.0	19
12 Douglas-fir	6	5.0	0.2	--	0.1	18

Data is from:

1-7	this study,
8-10	Biophysical Inventory, Southern Lakes Area, Yukon, unpublished data,
11	SW B.C. Engleman spruce stands - Klinka et.al. (1982).
12	The soils of the most productive ecosystems for the growth of Douglas-fir (in Klinka, et al. 1982).

8.1.2 Non-forested Below Treeline Communities

In the non-forested plots below treeline the major controlling factor appears to be soil drainage. This is not unexpected in view of the rather disjunct nature of the data set, which is readily divided into two major categories: well-drained outwash communities consisting primarily of *Betula*/lichen types and poorly drained *Carex* fens.

8.1.2.1 Fens

Fens are mires in which the vegetation is influenced by geogenous water (ground water which is in contact with mineral soils) (Horton and Vitt 1979). The Fennoscandian school of mire ecology suggests that there are three environmental gradients which are considered to be of primary importance in relation to mire vegetation. These gradients are ombrotrophic to minerotrophic, wet to dry, and mire margin to mire expanse. Vitt and Slack (1975) found that in mires, bryophytes are more sensitive indicators of the above-mentioned environmental gradients than are vascular plants. Horton and Vitt (1979) verified this with data from the Caribou Mtns of northern Alberta. They found that Sphagna are sensitive indicators of subtle changes in the environmental gradients of moisture, trophic status, and exposure. Of these, the variation from rich to poor and from wet to dry are the more significant parameters, with moisture being the primary factor controlling the distribution and abundance of the Sphagna species.

Unfortunately, within the present study, Sphagna were not identified to species. The pH, electrical conductivity and nutrient status were collected for the associated soils, not the mire water which is more important to mire species (Wali and Krajina 1973). Because the associated bedrock and mineral soils are acidic and rather nutrient-poor, one can probably infer that the fen water is oligotrophic to mesotrophic, reflecting the nutrient status of the underlying mineral materials. Horton and Vitt (1979) state that the greatest bryophyte diversity is found in poor fens, suggesting that bryophyte species richness, especially Sphagna, should be quite high in the Macmillan Pass area.

The DECORANA ordination placed the mire stands along a complex-gradient correlated with decreasing soil drainage and increasing nutrient status of the associated soils (Fig. 19). The relatively better drained SASP/HYSP community occurs at the dry end of the gradient, while the *Carex rostrata* community occurs at the wet end. The position of the CARO community at the far end of the X-axis suggests that *Carex rostrata* prefers moister, more nutrient-rich sites than *Carex aquatilis*.

It would appear that soil drainage, nutrients and depth to water table are the most important environmental factors associated with the fen communities. However, a complete bryophyte species list and nutrient status of the water would help clarify this.

8.1.2.2 Shrub Birch/Lichen Communities

The ordination of the *Betula* shrubland communities did not reveal any environmental factors which might control community composition and species distribution (Fig. 18). The gradients are short (2.0, 2.2 SD) and account for only 26% and 15% of the variation in the data.

When the *Betula* communities were ordinated with the wetland communities, the BEGL/CLST CT occurred at the left end of the X-axis, while the BEGL/MOSS CT's occurred further along it, suggesting that moisture, pH and nutrients may be influencing species composition (Fig 17). However, none of these variables was correlated with the axes of the separate *Betula*/lichen ordination. It is possible that the differences in species composition may be due to successional turnover. *Cladina stellaris* is shade-intolerant (Kershaw 1977). Over time the feathermosses may outcompete the lichens under the *Betula glandulosa* canopy (see discussion of communities, 8.2.3).

8.1.3 Alpine and Non-forested Subalpine Communities

Scott and Billings (1964) stated that low temperatures are generally accepted as the most important factors limiting plant growth in the alpine tundra region. They noted that other factors important to alpine tundra plants are summer air and soil temperatures, depth and duration of snow, length of growing season, available soil moisture, wind, soil development and soil depth and fertility.

Jonasson (1981) found that the distribution of winter snow is the most important factor controlling the composition of plant communities and the distribution of most plant populations of the low alpine *Betula nana* heaths in northernmost Sweden.

In both the alpine and non-treed subalpine zones in the study area, moisture seems to be the primary environmental factor controlling the distribution and abundance of species. Soil pH and available nutrients play a minor role. Snow depth, which is often considered important in alpine species distribution could not be considered in the present study. However, soil drainage and ecological moisture are often related to snow depth. Species normally considered to be chionophobous, such as *Alectoria ochroleuca, Cetraria cucullata, C. nivalis* and *Vaccinium uliginosum*, lie near the origin of the X-Y axes, with those, considered to be chionophilious such as *Cassiope tetragona, Polytrichum* sp. and *Veratrum viride* lie at the far ends of the X-Y axes, suggesting that snow depth may be an important factor (Larson and Kershaw 1974, Jonasson 1981).

Brown (1983) studied the relationships between vegetation types and the physical environment on a small parcel of land in the subalpine and alpine zones near Macmillan Pass (the Jason property). He found that the basic environmental factors that result in different vegetation types are climate, as influenced by elevation, and geological substrate. The influence of substrate was more significant than the local climatic influence of slope aspect. North- and south-facing slopes of mountains with similar substrates were more similar to each other than were slopes of similar aspect on mountains with differing substrate. North slopes with a pyritic shale substrate (acidic) supported mostly lichen and heath vegetation, while north slopes with a non-pyritic limestone shale (calcareous) supported a greater variety of species dominated by grasses and forbs. Drainage, due to topographic position or to substrate permeablility, had a significant influence on local vegetation pattern.

8.2 Community and Species Distribution

The majority of the vegetation community research conducted in the boreal forest region of the Yukon has been carried out in the southwestern and south-central portion of the territory, south of Beaver Creek (62°5'N) and west of Wolf River (133°E) (Douglas 1974, Orloci and Stanek 1979, Oswald and King 1980, Stanek 1980, Oswald et. al. 1981, Senyk et.al. 1981, Oswald et al. 1983, Boyd 1983). Further afield, but still in the western portion of the boreal forest, vegetation studies have been conducted along the Dempster Highway Corridor, in the Caribou forest region of northeastern British Columbia, and various areas of Alaska (Stanek et. al. 1981, Trowbridge et al. 1983, Neiland and Viereck 1977, Dyrness and Grigal 1979).

8.2.1 Tree Species Distribution

The most noticeable difference between the vegetation of Macmillan Pass and the southwestern Yukon and northern British Columbia is the distribution and abundance of the major tree species. Within the Macmillan Pass area black spruce and subalpine fir are the major tree species. White spruce is of lesser importance, aspen and balsam poplar have a limited distribution, and lodgepole pine is exceedingly rare. This is in contrast to the Southern Lakes area where white spruce is the most common tree species, occurring on virtually all sites, except very wet or dry ones, from the krummholz forms of subalpine sites to the highly productive alluvial sites and rivers and lacustrine basins (Oswald and King 1980, Boyd 1983). Black spruce, however, is not common in the southern Yukon, occurring most commonly in the Burwash-Uplands-Beaver Creek area and the Nisutlin River-Wolf River area. Throughout the rest of the southwestern Yukon white spruce often occurs on sites such as poorly drained bogs where one would normally expect black spruce. The absence of black spruce can possibly be explained by the more frequent occurrence of limestone bedrock and alkaline soils as black spruce has calciphobic tendencies (Morison pers. comm., Davies et. al. 1983, Krajina 1969). It is relevant to note that Trowbridge et al. (1983) stated that black spruce appears to be absent or very rare in the western portion of the Boreal White Spruce-Black Spruce Biogeoclimatic Zone in the Prince Rupert Forest Region of British Columbia.

Lodgepole pine, which is virtually absent from Macmillan Pass, is a common component of the boreal forest in the southwestern Yukon and northern British Columbia, occurring after fires and on well-drained eskers and outwash material.

8.2.1.1 Black Spruce

Black spruce is the most common tree species in the Macmillan Pass area, where it occurs on a wide variety of site types, from very poorly to well-drained soils, primarily on level to gently sloping lower slopes and valley floors.

Krajina (1969) described black spruce as a subhydric to hygric, submontane, submesotrophic stenotrophyte (growing on a narrow range of nutrient availability). It is well adapted to a microthermal, cold, continental, humid, submontane to montane, boreal forest climate. It is a highly frost-resistant tree, more tolerant to the pressure of an expanded volume of ice on the roots than is white spruce. Black spruce is shade tolerant, but on xeric to subxeric sites it is shade requiring.

Krajina (1980) stated that black spruce does not require as much calcium and magnesium as does white spruce. This is supported by the DECORANA ordination where the black spruce communities occur at the nutrient-poor end of the X-axis, while white spruce occurs at the nutrient-rich end.

Krajina (1980) described black spruce as the climatic climax in the Boreal White spruce-Black Spruce Zone in British Columbia. It is the principal successional tree following fire on both poorly and well-drained sites in the study area. Neiland and Viereck (1977) stated that, in Alaska, once black spruce stands with moss and peat mats 15 to 30 cm deep have developed, most fires will be followed by regeneration of much the same community as that which burned. In sites where the organic matter burned down to mineral material both birch and aspen can sometimes invade, but several factors tend to perpetuate black spruce: 1) their semi-serotinous cones, 2) the tendency for layered branches to remain alive in unburned moss and litter, and 3) the failure of fire to burn to mineral soil in the cold, usually wet moss and peat layers. Within the present study the presence of black spruce regeneration on well-drained sites with exposed mineral soil may be due to a lack of a local seed source for white spruce.

8.2.1.2 White Spruce

The limited distribution of white spruce in the present study area, where it tends to occur on imperfectly-drained alluvial material, could possibly be controlled by the low nutrient status of the soil. Krajina (1969) described white spruce as a mesic to subhydric, subeutrophic eurytrophyte, meaning that it occurs over a wide range of nutrient regimes, but grows best on subeutrophic edatopes where it can obtain an adequate supply of Ca, Mg and N. It cannot compete with black spruce in oligotrophic and submesotrophic bogs. Sutton (1969) stated that moderate fertility is needed for good growth, and that nutrient deficiencies depress its growth more than that of black spruce.

Climate should not be a limiting factor as white spruce is the most northerly occurring tree in the Canadian boreal forest (Sutton 1969) and is highly frost resistant (Krajina 1969). However, the range of sites accommodating white spruce become more limited with increasing severity of climate northwards, where sites are characterized by good drainage or fertile soils (Sutton 1969).

It is therefore postulated that the distribution of white spruce in the Macmillan Pass study area is controlled primarily by soil fertility. This hypothesis is supported by both the species and stand ordinations where white spruce communities occur at the nutrient-rich, high pH end of the complex -gradient. It is also supported by statistical tests, i.e. sites with white spruce are more nutrient-rich than sites without white spruce.

Slope aspect may be a minor factor in influencing the distribution of white spruce. Chi-square tests of independence demonstrated that white spruce occurs more often than expected by chance on southerly-facing slopes and level sites (Table 19). This is also indicated by the ordination where slope aspect is a minor component of the complex-gradient.

8.2.1.3 Subalpine Fir

While subalpine fir is the common treeline species in the Macmillan Pass area it is absent from a large portion of the southwestern Yukon, where white spruce is the treeline species. This difference can possibly be explained by climate. Subalpine fir is a mesic to subhydric subeutrophyte preferring a microthermal, continental, humid climate with a short vegetative season (Krajina 1969). As most of the southwestern Yukon falls in the rain shadow of the St. Elias Mtns., rainfall is considerably less than in Macmillan Pass (Wahl nd.). Subalpine fir does, however, occur in the southwest corner of the Yukon where it benefits from the Pacific influence and in the south central Yukon where the rain shadow effect is lessened.

Subalpine fir is extremely shade tolerant, and is highly frost resistant. Its best growth is achieved on soil high in Ca and Mg (Krajina 1969). However, in this study, sites with subalpine fir do not have significantly higher levels of Ca and Mg than sites without subalpine fir.

The presence of subalpine fir in Macmillan Pass may explain the discrepancies in the upper limit of tree growth between the study area (1300 m) and the southwestern Yukon (1000 m), where white spruce is the common treeline species (Oswald et al. 1980).

It is noteworthy that subalpine fir is approaching both its northern and eastern limits of occurrence in the Macmillan Pass area (Porsild and Cody 1982).

8.2.1.4 Lodgepole pine

The almost complete absence of lodgepole pine from the study area is not easily explained. Lodgepole pine was observed only once in the study area, on a well-drained southeast-facing site (1175 m) between Lewis Lake and the Canol Road, near the southern boundary of the study area. Porsild (1951) noted that pine was totally absent on the lower Ross River and the Pelly River near the townsite of Ross River. However, he recorded a few isolated groups of trees in the Ross River Valley between Mile 174 and 178 of the Canol Road, which is just south of the present study area.

Krajina (1969) described lodgepole pine as occurring on xeric to subhydric, oligotrophic to mesotrophic sites, where Ca is not abundant in the top soil horizon. It requires less nutrients than white spruce (Sutton 1969). Lodgepole pine is frost hardy, and its general climatic amplitude is the widest of any coniferous tree in British Columbia (Krajina 1969). It has been observed as far north in the Yukon as 64°20′ latitude and at elevations up to 1700 m (Zasada et.al. 1977). Therefore, neither nutrients nor climate should prevent lodgepole pine from occurring on the better drained sites in the Macmillan Pass study area. Its absence may be explained historically if the species has not extended its range to its ecological limit after the last glacial retreat. Isolated pine pockets suggest that they may have survived the last ice age on nunataks (Oswald pers. comm.). Pine is absent in interior Alaska. However, initial trials with seed collected near Whitehorse indicate that it grows well near Fairbanks (Zasada et. al. 1977).

8.2.2 Comparison to Plant Communities of Other Regions

8.2.2.1 Treed Communities

While the relative distribution of the major tree species is different between Macmillan Pass and the southern Yukon and northern British Columbia, many of the communities in which the trees occur are similar. Direct comparisons are often difficult due to different methods of synthesizing and naming communities.

a. White spruce Communities

White spruce/feathermoss forest is the most common general vegetation type occurring in the southwest-southcentral Yukon and northern British Columbia. It occurs on a wide variety of habitats but rarely on imperfectly drained Cryosolic soils as is common in the Macmillan Pass area.

Trowbridge et.al. (1983) described White Spruce-Moss subassociations occurring in northern British Columbia in the Prince George boreal forest region. These subassociations are dominated by white spruce and feathermosses. They have a poorly developed shrub layer, with *Ledum groenlandicum* dominating in the east and *Shepherdia canadensis*/*Viburnum edule* dominating in the west. They typically occur on moderately well to well-drained, acidic Luvisols or Brunisols formed on morainal or fluvial materials. These subassociations are most similar to the morainal PIGL/HYSP subtype occurring in the study area, except that they appear to have fewer understory species. The white spruce/feathermoss types in the present study occur on more poorly drained Cryosolic and Gleysolic soils. The alluvial white spruce/feathermoss subtypes appear to be most similar to Trowbridge et al.'s White Spruce/Horsetail association, which occurs on moderately well to well-drained sandy Brunisols, Regosols and Gleyed subgroups, developed on flood plains. This association differs from the white spruce/feathermoss subtype in that *Pyrola secunda* and *Mitella nuda* are common in the herb layer, while *Mnium* sp. is common in the bryophyte stratum.

Neiland and Viereck (1977) described a Bottomland White Spruce Rose-feathermoss community which occurs in most regions of interior Alaska. It is very similar to the alluvial PIGL/HYSP and PIGL/PLSC subtypes described in the present study. *Hylocomium splendens, Pleurozium schreberi* and *Rhytidiadelphus triquetrus* are the common mosses forming a thick carpet on the forest floor. *Rosa acicularis* is the most common shrub, followed by *Viburnum edule* and *Alnus crispa*. The most important herbs are *Equisetum* sp., *Linnaea borealis, Geocaulon lividum* and *Pyrola* spp. This Alaska community is considered a successional stage between balsam poplar and black spruce. Neiland and Viereck also described an Upland White Spruce type, occurring on slopes extending up to treeline. Its understory varies depending on tree canopy cover. *Salix, Alnus, Vaccinium uliginosum, Empetrum nigrum,* and *Vaccinium vitis-idaea* are common shrubs. *Hylocomium splendens* and *Pleurozium schreberi* are the most abundant mosses, though *Dicranum fuscescens* is common. This type would appear to occur on better drained sites, and does not readily translate into any of the communities in the present study, though it may be most similar to the morainal PIGL/HYSP subtype.

Stanek (1980) surveyed 323 plots along the Yukon Territory portion of the Alaska Highway. He recognized eight white spruce types, three of which (PIGL/HYSP/PEPA, PIGL/COCA/HYSP/PLSC-PEAP and PIGL/SALIX-AUPA/HYSP) are similar to the white spruce/feathermoss communities occurring in the present study. All of Stanek's communities have several phases, and occur on a wide range of drainage conditions from impeded to well-drained.

Douglas (1974) recognized six white spruce communities in the Alsek River Region of Kluane National Park, Y.T. One of these communities, White spruce/Shepherdia (closed phase) translates to the PIGL/HYSP community found in the present study. It occurs on somewhat different sites, i.e. well-drained, mesic to moderately dry glacial till and alluvial and lacustrine deposits. *Shepherdia canadensis* replaces *Salix* sp. as the tall shrub. Forb and low shrub composition is similar. The ground is carpeted by a continuous bryoid mat dominated by *Hylocomium splendens* and *Drepanocladus uncinatus*.

Oswald et al. (1981) described a total of 61 white spruce community types occurring in the East Kluane area of the Yukon. Many of these are successional stages. White spruce/feathermoss, White spruce-Balsam poplar/ *Shepherdia canadensis* /feathermoss and White spruce-Balsam poplar/ *Alnus*/feathermoss are the most similar to the white spruce/feathermoss communities described from the present study.

Boyd (1983) recognized 12 white spruce communities occurring in the Southern Lakes Regions of the Yukon. White spruce/Feathermoss is most closely related to the morainal PIGL/HYSP subtype, while White spruce/*Equisetum* is most similar to the alluvial PIGL/HYSP CT.

While only four white spruce communities, three of them white spruce/feathermoss types, could be recognized in the Macmillan Pass study area, numerous other white spruce types occur in the southern Yukon and northern B.C. Some of these are similar to the black spruce communities in the study area, except that white spruce replaces the black spruce. White spruce communities totally absent from the study area are those occurring on better drained sites, such as White Spruce/Bearberry, White Spruce/Grass, White Spruce/Lichen, White Spruce/Dryas and White Spruce/Soapberry (Oswald et al. 1980, 1983). *Shepherdia canadensis, Arctostaphylos uva-ursi*, and *Dryas* spp. are all rare in the study area. The occurrence of *Dryas* spp. and *Shepherdia canadensis* is restricted to neutral or calcareous soils.

b. Black Spruce Communities

Black spruce-dominated communities are common in Alaska, the northern and eastern Yukon and northeastern British Columbia (Neiland and Viereck 1977; Trowbridge 1983; Stanek et.al. 1981; Oswald et al. 1980). Six black spruce communities were recognized in the Macmillan Pass area.

Dyrness and Grigal (1979) recognized four black spruce communities along a 3-km transect near Fairbanks, Alaska. Their closed Black Spruce/Feathermoss community, which occurs on poorly drained permafrost soils, is most similar to the PIMA/HYSP-Phase I community in the present study. An open Black Spruce/Feathermoss community is possibly similar to the ABLA-PIMA/PLSC-CLST phase of the ABLA-PIMA/CLST community A transitional zone, open Black Spruce/*Sphagnum* community appears to be intermediate between the PIMA/SPH-CLST and PIMA/PLSC-SPH communities. One community, Black Spruce woodland/*Eriophorum*, does not have a counterpart in the present study area.

Stanek (1980) described two black spruce communities occurring along the Alaska Highway in the Wellsley Lake Ecoregion; *Picea mariana/Ledum groenlandicum/Hylocomium splendens* and *Picea mariana/Ledum palustre/Eriophorum vaginatum/Aulacomnium palustre*. The former community, which occurs on level to moderately sloping permafrost sites, is very similar to the PIMA/HYSP community found in the present study. The latter community does not have an equivalent in the present study.

Boyd (1983) described three black spruce communities; Black Spruce/*Ledum*, Black spruce/Bogmoss and Black Spruce/*Sphagnum*, which occur in the Southern Lakes region of the Yukon. Black Spruce/*Ledum* is most similar to PIMA/PLSC-SPH and Black Spruce/*Sphagnum* closely resembles PIMA/SPH-CLST.

Trowbridge et al. (1983) recognized four Black Spruce associations; Lodgepole Pine-Black Spruce-Feathermoss, Black Spruce-Labrador tea-Horsetail, Tamarack-Black Spruce-Moss and Black Spruce Bog, occurring in northeastern British Columbia. The associations dominated by lodgepole pine and tamarack do not have counterparts in the

Macmillan Pass area, as neither of these species occurs there. However, the Lodgepole Pine-Black spruce association is possibly very similar to the PLSC-Phase II of the ABLA-PIMA/CLST community. *Pleurozium schreberi* is the dominant moss in both regions. The shrub layer is similar, except that *Arctostaphylos uva-ursi*, which is dominant in the B.C. association, is missing from Macmillan Pass. Soil type, drainage and parent material are similar. The Black Spruce-Labrador Tea-Horsetail association is most similar to the PIMA/feathermoss communities, while the Black Spruce bog association, which occurs in Crysolic soils, is most similar to the Black Spruce/Sphagnum types of Macmillan Pass.

c. Alpine fir Communities

Descriptions of subalpine fir communities are not common for the region north of the 60th parallel.

Oswald et al. (1983) stated that subalpine fir is the dominant tree in the lower subalpine zone in the eastern portion of the Carmacks-Ross River area, Y.T. The understory consists of shrub birch-willow/lichen where trees are well-dispersed. *Ledum groenlandicum* becomes a principal species on moist, usually cooler sites. Where tree cover is dense (60-70%), feathermosses may be the primary understory cover on mesic sites, brown mosses on more moist sites and lichens on drier sites.

The two major subalpine fir communities present in the eastern half of the Southern Lakes area are Subalpine Fir/Feathermoss and Subalpine Fir/Shrub Birch/Lichen (Boyd 1983). Neither the latter community nor the Subalpine Fir/Shrub Birch described by Oswald et al. (1983) were recognized in the Macmillan Pass region.

8.2.2.2 Feathermoss Composition of Forest Communities

The understory of many of the forest communities is dominated by feathermoss. However, many researchers do not distinguish between the various species.

Oswald et al. (1981) found that *Hylocomium splendens* is the dominant feathermoss in the East Kluane area, except in the central and western sections where *Thuidium abietinum* is the dominant moss. They suggest that this difference could be due to differing soil alkalinity. Douglas (1974), in the Alsek River valley, found *Hylocomium splendens* and *Drepanocladus uncinatus* under well drained white spruce, and *Pleurozium* *schreberi* and *Hylocomium splendens* on more poorly drained white spruce sites. Viereck et al. (1983) in interior Alaska found *H. splendens* was abundant in both black and white spruce stands, while *P. schreberi*, although occurring in most white spruce stands, was the dominant feathermoss in most black spruce stands. Skre (1979) found that near Fairbanks, Alaska, the relative cover of *Hylocomium splendens* was highest on nutrient-rich, white spruce sites, while the relative cover of *Pleurozium schreberi* was highest on nutrient-poor black spruce sites with permafrost soils.

The present study supports the findings of Skre and Oechel (1979) and Viereck et.al. (1983). *Hylocomium splendens* and *Pleurozium schreberi* are the dominant feathermosses, with *H. splendens* more often associated with white spruce and *P. schreberi* with black spruce. The cover of *H. splendens* is significantly and positively correlated with the cover of *Picea glauca* (r=.43) and *Abies lasiocarpa* (r=.29) but not with the cover of *Picea mariana* (r=-.03). The cover of *P. schreberi* is postively and significantly correlated with the cover of *Picea mariana* (r=.30), but not with the cover of *Picea glauca* (r=-.14) or *Abies lasiocarpa* (r=.10).

Lee and La Roi (1979) have demonstrated that *Pleurozium schreberi* is not as prominent at higher elevations as is *Hylocomium splendens* . In the present study the cover of these two feathermosses was not signficantly correlated with elevation within the forested zone. However, the mean elevation of sites with *Pleurozium schreberi* is significantly lower than the mean elevation of the forested sites (Table 20).

It is of interest to note that *Hylocomium splendens* occurs on less acidic, more nutrient rich sites than *Pleurozium schreberi*. All *Hylocomium* communities lie at the high pH, nutrient-rich end of the X-axis of the stand ordination. This could prove to have management implications, allowing resource workers to recognizes poor vs. moderately rich sites in the field. Skre et al. (1983) stated that the nutrients available to mosses depends on the nutrient status of the soil, successional stage of the community, and indirectly on tree cover, slope and aspect of the site. However, they do not state the pathway by which more fertile soil makes more nutrients available to the feathermosses. Tamm (1953) demonstrated that feathermosses do not receive nutrients from below, but are supplied nutrients from atmospheric sources and tree leachate carried to the moss by rain.

8.2.3 Non-Forested Below Treeline Communities

Trembling Aspen/Grass, Trembling Aspen/Sage, Pine/Lichen, White Spruce/Lichen and Sage/Grass communities which occur in the southern Yukon on well-drained, coarse textured glacial outwash, south-facing slopes of kames and on floodplain terraces (Oswald et al. 1980, 1983) are absent from the study area; they are replaced by BEGL/CLST and BEGL/MOSS communities dominated in the shrub layer by *Betula glandulosa*. The ground is covered by an extensive bryoid mat, dominated by *Cladina stellaris*, or occasionally by feathermosses with a high component of *C. stellaris*.

Many authors have described open lichen woodlands in the eastern boreal forest region that seem to be ecologically very similar to the BEGL/CLST community in the study area, except that black spruce replaces the shrub birch (Kershaw 1977). There is general agreement among the early researchers, Hustich, Fraser, and Ahti, that: 1) the lichen woodland is larley dominated by *C. stellaris*; 2) it probably represents a long-term phase during the recovery sequence following fire, as *C. stellaris* is the slowest-growing of the *Cladinae* lichens, and 3) it is restricted to dry, coarse-textured areas such as elevated deltas, glaciofluvial deposits, river terraces, ridges, plateaus, etc., where the growth and abundance of associated tree species is reduced to such an extent that the growth of *C. stellaris*, which is shade intolerant, is not restricted by competition for light (Kershaw 1979).

Ahti (1967, in Kershaw 1979) suggested that optimal lichen growth is dependent on high humidity as lichen metabolism is dependent on thallus moisture. In addition, he suggested that during lichen establishment soil pH is important, with acidic soils being preferred, neutral soils being tolerated, and calcareous soils avoided.

These conditions, i.e. high humidity and coarse-textured, acidic soil, occur in the study area, and imply that lichen woodlands should occur. The reason black spruce is replaced by *Betula glandulosa* to form lichen shrublands can only be postulated upon. It could possibly be due to drainage so extreme that black spruce cannot become established. However, Kershaw and Field (1975) have demonstrated that lichen mats alter their micro-environment, acting as a soil mulch. Soils beneath the mat were found to be at field capacity throughout most of the growing season, and soil temperatures were considerably cooler than similar areas where there was no lichen mat. These cooler soil temperatures could possibly offset the increased soil moisture and prevent the successful establishment of spruce seedlings. Fisher (1979) found that a mulch of *C. stellaris* significantly reduced growth as well as N and P concentrations in black spruce seedlings, though it did not retard germination. He concluded that poor growth of conifers on *Cladinae*-dominated sites is partially due to an allelopathic influence of the lichen.

Another factor which could possibly limit tree growth is decreased nutrient status. Multiple range tests have demonstrated that BEGL shrublands have significantly lower nutrients than the forest communities (Tables 15-18).

Fire does not appear to play a role in the absence of conifers from the lichen shrublands, as snags were not observed. However, it could play a role in maintaining the lichen component of the shrubland. Kershaw (1977) stated that without fire the *Cladina* woodlands would develop a greater tree density, leading eventually to a closed canopy. This would result in the replacement of the photophilic lichens by shade-tolerant feathermosses. The existence of a BEGL/MOSS community, with a high component of lichens, occurring on sites very similar to those where BEGL/CLST communities occur, suggests that possibly the BEGL/MOSS CT's are a later successional stage of BEGL/CLST.

Kershaw (1983) described a *Betula glandulosa-Cladina stellaris*-Moss community which occurs along the Canol Road at lower elevations on the Northwest Territories side of the divide. The common moss species include *Hylocomium splendens* and *Polytrichum* spp., but not *Pleurozium schreberi*, which was common in the present study. Differences in shrub height were attributed to differences in snow depth and exposure (Kershaw 1983)

References to similar shrub/lichen communities occurring elsewhere in the Yukon Territory could not be found.

8.2.4 Alpine and Non-forested Subalpine Communities

The alpine and non-forested subalpine vegetation of the Macmillan Pass area is most easily made comparable to the vegetation communities of other researchers, both within and outside the present study area, if the communities are grouped into broad, heterogeneous assemblages based on growth-form. These groups are as follows:

subalpine shrub, alpine heath, moist forb-graminoid, graminoid-moss and wetland communities.

8.2.4.1 Subalpine Shrub Communities

The subalpine communities are characterized by medium-height shrubs. *Betula glandulosa* is prominent on the better drained sites, while *Salix* spp. are common on moist sites, especially snow-melt depressions. Understory is variable depending on drainage. Bryophtes, especially *Pleurozium schreberi* and *Hylocomium splendens*, are common associates of *Salix* spp. Lichens or submesic mosses (*Polytrichum* sp.) are common associates of *Betula* on gently sloping, coarse-textured sites, while grasses, especially *Festuca altaica* and *Calamagrostis canadensis* are common associates on steep, south-facing slopes.

Both Brown (1983) and Amax (1979) described Birch-lichen shrublands which are most similar to the BEGL/CLST/STSP community described in this study. Oswald et al. (1983, 1981a, 1981b) and Boyd (1983) described similar subalpine communities from elsewhere in the Yukon, except that the thick carpet of *Cladina stellaris* is replaced by a more sporadic cover of *Cladina mitis, C. rangiferina* and Cetrarioid lichens.

8.2.4.2 Alpine Heath

The alpine heath communities can be subdivided into two major groups, lichen heath and bryophyte heath communities. The better drained, more exposed sites are dominated by lichen heath; the prevalent lichens, which almost completely carpet the ground are *Alectoria ochroleuca, Stereocaulon* spp., *Cetraria* spp. and, more rarely, *Cladina stellaris. Vaccinium uliginosum, V. vitis-idaea* and *Arctostaphylos rubra* are the dominant heaths. Commonly associated graminoids are *Hierochloe alpina* and, at lower elevations, *Festuca altaica*.

Vaccinium uliginosum, Alectoria ochroleuca, Cetraria cucullata, and *C. nivalis* are considered chionophobous species (Larson and Kershaw 1974, Jonasson 1981). *Vaccinium vitis-idaea* and *Stereocaulon paschale* are described as species with a wide snowdepth amplitude (Jonasson 1981).

Chi-square tests of independence indicate that *Vaccinium uliginosum, V. vitis-idaea* and *Festuca altaica* occur more often than expected by chance on southerly-facing slopes, while *Alectoria ochroleuca, Stereocaulon* spp. and *Hierochloe alpina* occur more often than expected on apices and upper slopes on poorly developed soils. The preference of *Vaccinium* spp. for southerly aspects is in contrast to the site preference found below treeline, where *V. uliginosum* is significantly more common on east, north, and level sites and *V. vitis-ideae* occurs independently of slope aspect (Tables 7 & 19). Porsild (1951) described *V. uliginosum* as a common species of the southeastern Yukon where it occurs on a great variety of habitats and where, accordingly several ecological forms occur. A tall, large-leaved form occurs in the lowlands in wet areas, while a more or less prostrate form is found on rocky ledges in the mountains. Porsild and Cody (1980) described it as common on acidic soils, in dry as well as moist place.

Vaccinium vitis-idaea is described by Porsild (1951) as one of the most common plants of the Canol area, rarely absent in muskegs, spruce forests, heaths, sunny cliffs, etc., and by Porsild and Cody (1980) as dominant on open, acid and turfy sites.

Amax (1979) and Brown (1983) described lichen-heath communities which differ from the ones described in this study in that *Cassioppe tetragona* is often the dominant heath.

Within the present study *C. tetragona* was more often associated with a thick carpet of bryophytes, forming bryophyte-heath communities which, though occurring on all aspects, are most common on northerly-facing sites and shallow depressions. Polunin (1959) described *C. tetragona* as abundant almost everywhere in dry exposed situations in the arctic and arctic-alpine areas of the northern hemisphere. In contrast, Porsild (1951) describes *C. tetragona* as common on north-facing alpine slopes and in other places such as timberline spruce and fir forests where the snow remains late. Amax (1979) found that *Cassiope tetragona* occurred on all aspects within the MacTung area (a mining property located along the Yukon-Northwest Territories border, just north of Macmillan Pass), and suggested that Porsild found it predominantly on north slopes because he botanized at lower elevations. However, Chi-square tests of independence demonstrate that while *Cassiope tetragona* occurred on all aspects in the present study, it occurred more often than expected by chance on north-facing slopes (Table 7). Oswald et al. (1983) stated that it occurs sporadically in many of the alpine communities in the Carmacks-Ross River area, but becomes prominent to dominant in any areas where snow accumulates and is slow melting.

Alpine communities dominated by *Cassiope tetragona* are not noted as being common elsewhere in the Yukon Territory. The lichen-heath tundra in other regions of the Yukon and on the Northwest Territories side of Macmillan Pass are differentiated from those described in this study by having *Dryas integrifolia* as a dominant species (Oswald et al. 1981, Kershaw 1983).

8.2.4.3 Forb-Graminoid Communities

An interesting feature of the alpine-subalpine vegetation is the occurrence of species-rich forb-graminoid meadows. Porsild (1951) describes these meadows in the following manner:

> "Peculiar subalpine meadows or prairies were noted chiefly in the valleys of the Ross and Macmillan Rivers and are believed to be remnants of former and more extensive grasslands. They were invariably found on well-drained fertile soils up to the 4000 ft level. A number of grassland species are peculiar to these meadows and were not noted elsewhere along the Canol Road."

and

> "Of the large number of plant communities occurring above timberline, the most remarkable and interesting are the rich alpine 'flower gardens' peculiar to favourably exposed plateaux and gentle slopes on well-drained soils fed by water from snowdrifts or water stored in the thick mantle of well weathered soils of these upper slopes. Here at elevations between 4,500 and 5,600 ft. the richest and most interesting assemblages of plants were found."

Above-treeline communities described in this study which fall into this subalpine/alpine meadow 'flower garden' category are CACA/HYSP, VEVI/HYSP, FEAL/FORB, CAPO/PLSC and SETR/AUSP. Communities below treeline which also fit into this category are FEAL/FORB, ARLA/FORB and FEAL/HYSP.

Similar communities have been described by other researchers. Brown (1983) described a forb meadow community with the most common species being *Senecio triangularis* and *Valeriana sitchensis*. Amax (1979) described two such communities; Moist Forb Tundra (1480 - 1675 m) and Mesic Forb Tundra (1525 - 1830 m). The Mesic Forb Tundra is somewhat different from the communities described in the present study where *Luzula arctica, Artemesia arctica* and *Sibbaldia procumbens* are not dominant species as Amax found. The Moist Forb Tundra is more similar to the communities described here, having *Mertensia paniculata* and *Senecio triangularis* as the most abundant species. Third in abundance is *Myosotis alpestris* which was not commonly recorded in the study area. As with the communities described in the present study, these communities have a well-developed moss-lichen layer with >40% coverage. The dominant bryophytes in the Mesic Forb Tundra are *Polytrichum juniperinum* and *Dicranum elongatum*, while *Hylocomium splendens* is dominant in the Moist Forb Tundra. Unlike the present study graminoids do not contribute significantly to the flora of the Moist Forb Tundra.

Kershaw (1983) did not describe similar forb communities along the Canol Road east of the Macmillan Pass divide. Oswald et al. (1983) described herb meadows occurring on nutrient-rich, perpetually moist to wet, topographically protected sites in the Carmacks-Ross River area of the Yukon. *Carex* and *Eriophorum* are often dominant, but the striking feature is the profusion of forbs of which *Aconitum, Solidago, Pedicularis, Anemone, Campanula, Senecio, Erigeron, Artemisia, Polygonum, Saxifraga* and *Ranunculus* are the common associates.

8.2.4.4 Graminoid/Moss Communities

Graminoid/moss communities are a less significant component of the Macmillan Pass alpine vegetation, and are often very similar to either of the moss-heath or subalpine shrub communities, except that the cover of graminoids is much higher. In one such community, FEAL/POJU (IS=0.538), the plots are grouped together because of high cover values of *Festuca altaica* and *Polytrichum juniperinum*, both rather ubiquitous species. However, despite the rather high IS, these plots appear visually quite different from each other, and occur on markedly different sites.

The CAPO/AUPA community occurs on more poorly drained sites (mesic to subhydric). It is similar to the Graminoid Moss Tundra, the Sedge-Moss Tundra and the Miscellaneous Moss-*Carex podocarpa* communities described by Amax (1979), Brown (1983) and Kershaw (1983).

8.2.4.5 Wetland Communities

Wetland subalpine communities similar to those described in this study have also been described by Amax (1979) and Brown (1983). However, they record a higher cover of *Eriophorum* species than found in the present study. Kershaw (1983) did not recorded similar communities occurring east of the Macmillan divide. Oswald et al. (1983) noted the occurrence of subalpine wetlands in the Carmacks-Ross River area, but descriptions of such subalpine communities are not found for the remainder of the southwestern Yukon.

8.3 Landscape Profiles

Figures 20 to 23 illustrate the placement of some of the major community types in the landscape. These cross-sectional diagrams are based on sites described during foot traverses down slopes.

Figures 20 and 21 are typical of the terrain in the Hess Mtn. Physiographic region, where there is both an upper and lower treeline. The narrow valley floors are characterized by poorly drained alluvium supporting willow communities. Figure 20 and Plates 33 to 45 illustrate the change in soil development and drainage down a slope: the alpine zone is characterized by an Orthic Regosol occurring on a steep colluvial slope; well-drained Brunisols occur on the moderately steep upper and midslope supporting subalpine fir; and moderately well-drained Brunisols occur on the gentle lower slope, supporting white spruce. Recent alluviul material along the edge of an intermittent stream is sandwiched between rapidly drained, coarse textured, glacio-fluvial material.

Figure 21 illustrates a cross-sectional diagram of a narrow, subalpine valley on the southwest-facing flank of Keele Peak. The alpine slope, though colluvium, is stable enough for Brunisolic soils to have developed. Elevation and climate are such that subalpine fir survives in a krummholz form (See Plate 2 in Results). Glaciofuvial material is absent from the valley floor.

Figure 22, also occurring in the Hess Mtn. Physiographic region, is somewhat different from the proceeding two profiles in that it is lacking a lower treeline. It represents a northwest-facing profile down the flank of Keele Peak across a lacustrine plain to the Hess River. The alpine zone is dominated by *Cassiope tetragona* , which has a tendency to occur on northerly-facing slopes. Subalpine fir occurs on the gently sloping mid and lower slopes. The undifferentiated parent material is possibly a beach ridge resulting from the lake formed when the Hess River was blocked during deglaciation. Black spruce occurs on the lacustrine material found on the lower slope and the valley floor. The lower slope is somewhat better drained than the valley floor, supporting a PIMA/HYSP community formed on a Regosolic Static Cryosol, while the valley floor supports a

PIMA / SPH-CLST community where the spruce are more sparse. The soil is a Gleyed Static Cryosol.

Figure 23 is typical of the more gently rolling terrain of the Pelly Plateau physiographic region. The alpine zone is characterized by relatively well-developed Brunisolic soils occurring on morainal material. The gentle upper and midslopes support subalpine fir, the mid and lower slopes support black spruce. The valley floors are dominated by fens. The edges of the fens are typified by an imperfectly to poorly drained organic veneer grading into a very poorly drained mesic oraganic blanket and finally into free standing water.

Site Position	Upper Slope	Upper Slope	Mid Slope	Lower Slope	Valley Floor	Valley Floor
Community	ERICAD/FEAL/PLSC	ABLA/EMNI/POJU	ABLA/EMNI/POJU	CONIFER/PLSC	SASP/CAAQ	BEGL/MOSS
Soil Drainage	Well	Well	Well	Moderately Well	Poorly	Rapidly
Soil Subgroup	O R	E DYB	O DYB	O EB	RG	E EB

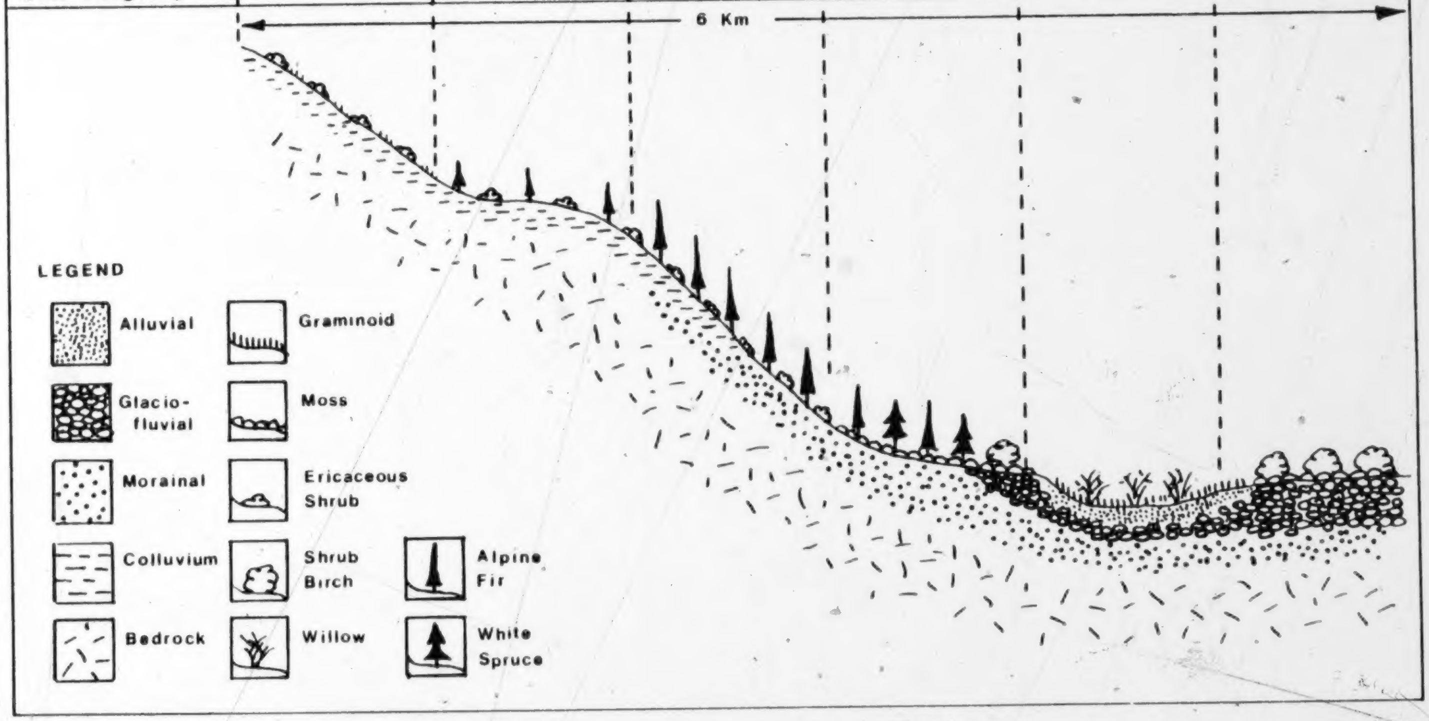

6 Km
LEGEND
Alluvial
Glacio-fluvial
Morainal
Colluvium
Bedrock
Graminoid
Moss
Ericaceous Shrub
Shrub Birch
Willow
Alpine Fir
White Spruce

Figure 20. Cross-sectional representation of a south-facing slope, Hess Mtn. Physiographic region (63° 02′ N, 130° 50′ W), based on 6 sites sampled along a foot traverse. Elevational range is from 1250 - 1800 m. Plates 32 - 49 illustrate the individual sites and soils.

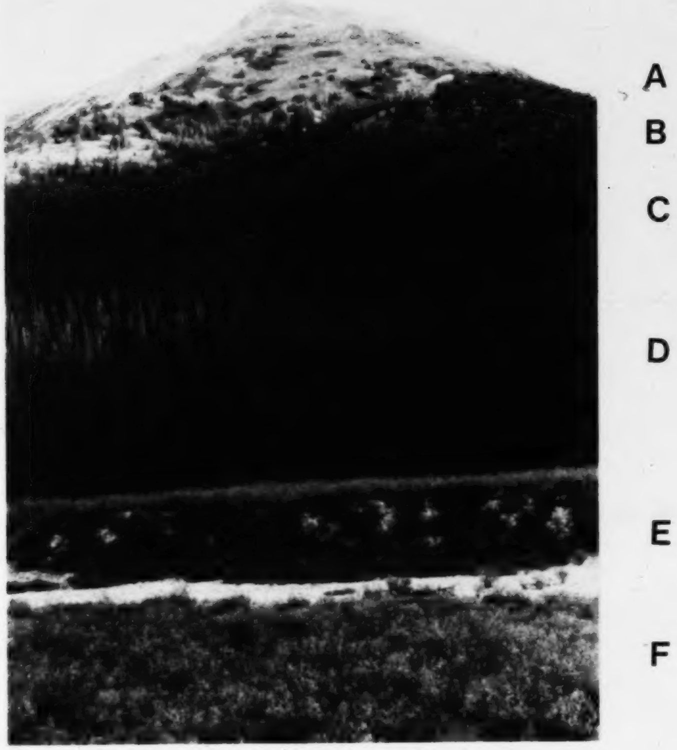


Plate 33. This photograph shows the slope illustrated diagramatically in Figure 20.
Zones are as follows: A - ERICAD / FEAL / PLSC TCT
B - ABLA / EMNI / POJU CT
C - ABLA / EMNI / POJU CT
D - CONIFER / PLSC CT, PIGL ST
E - BEGL / PLSC CT
F - SASP / CAAQ CT
This photograph and those in plates 33 - 44 were taken on July 18, 1981.

Plate 34. ERICAD/FEAL/PLSC TCT, Site 230, 1760 m. This site is dominated by *Festuca altaica* (25% cover). *Pleurozium schreberi* is the dominant bryophyte (20% cover). Shrubs present are *Vaccinium uliginosum* , *V. vitis-idaea, and Empetrum nigrum* . Total shrub cover is ca. 15%. *Artemisia arcticum* is the dominant forb (6% cover).

Plate 35. Orthic Regosol, Site 230. Horizon order is as follows:
LFH, 5 - 0 cm. 10YR 2/2 m, abundant fine, very fine and medium roots.
BC, 0 - 28 cm. 2.5Y 4/3 m, silt loam, granular, very friable, abundant very fine, fine and medium roots, angular and subangular gravel and cobbles
CB, 28 - 60 cm. 2.5Y 4/2 m, silt loam, plentiful very fine and fine roots, angular and subangular gravel and cobbles.

Plate 36. ABLA/EMNI/POJU CT, Site 231, 1760 m. The ground cover in this site is dominated by lichens and prostrate shrubs. *Stereocaulon pasahale* is the dominant lichen (12%) cover, *Cladina stellaris* is almost as common (8% cover). *Cassiope tetragona* (15%) and *Empetrum nigrum* (7%) are the common shrubs. *Polytrichum juniperinum* is not prominent on this site (2% cover). Trees are scattered.

Plate 37. Eluviated Dystric Brunisol, Site 231. Horizons are as follows:
L, 2 - 0 cm.,
Ah, 0 - 2 cm., 10YR 2/1 m, silt loam, plentiful fine and medium roots.
Ae, 2 - 4 cm., 10YR 5/2 m, loam, few fine and medium roots.
Bm, 4 - 7 cm., 10YR 6/6 m. loam, few fine, medium and coarse roots.
C(Ash), 7 - 12 cm., 10YR 7/2, loam, few, fine and medium roots.
Ah, 12 - 16 cm., 10YR 3/3, loam, plentiful fine and medium roots.
Bm, 16 - 43 cm., 10YR 5/5, loam, few very fine and fine roots, angular and subangular gravel.
BC, 43 -60 cm., loamy sand, very few very fine roots, angular gravel and cobbles.

Plate 38. ABLA/EMNI/POJU CT. Site 232. 1480 m. This site occurs further down the slope than the previous ABLA site, trees are less scattered. *Picea glauca* is present, though *Abies lasiocarpa* is the dominant species. The lichens are replaced by byrophtes with *Dicranum* sp. being prominent (25% cover). *Cassiope tetragona* is lacking and *Empetrum nigrum* (15% cover) is the dominant shrub.

Plate 39. Ortho Dystric Brunisol. Site 232. This soil is not as well-developed as the Brunisol further up the slope. Only a thin FH is present over the ash layer which is 9 cm thick.

Plate 40. CONIFER/PLSC CT. Site 233. 1340 m. This is a level site situated on the lower slope. *Picea glauca* is the dominant tree species (10% cover), though both *Picea mariana* (3%) and *Abies lasiocarpa* (2%) also occur. The ground is carpeted by a mixture of *Hylocomium splendens* and *Pleurozium schreberi* .

Plate 41. Orthic Eutric Brunisol. Site 233. This soil is differentiated from the preceeding soils by the thicker LFH horizon. Horizons are as follows:
LF, 14 - 0 cm., 10YR 2/2, abundant very fine, fine, medium and coarse roots.
C(Ash), 0 - 6 cm., 10YR 7/2, loam, amorphous, few very fine and fine roots.
Ae, 5 - 15 cm., 10YR 3/1.5, loamy sand, single grained, few very fine and fine roots.
BM, 15 - 31 cm., 2.5Y 3.5/3, loamy sand, single grained.
C, 31 - 47 cm., 2.5Y 3/1, loamy sand.
R, > 47 cm.

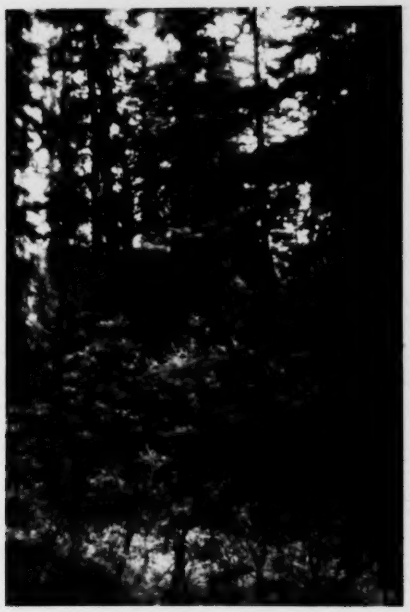
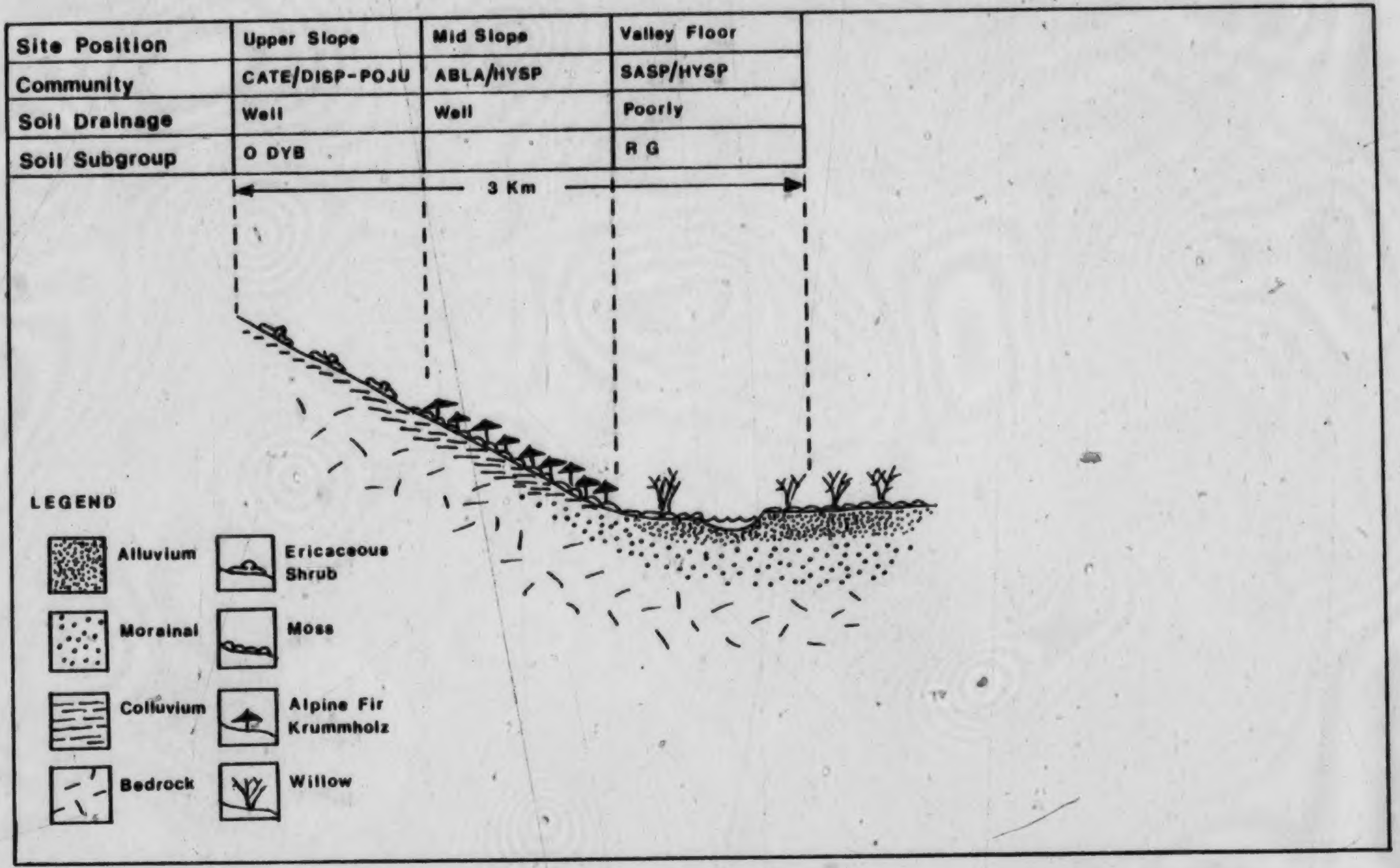


Plate 42. BEGL/PLSC CT, Site 235, 1250 m. This is a typical submesic BEGL community. The understory is dominated by *Cladina stellaris* (30% cover) and *Pleurozium schreberi* (55% cover). Forbs are absent and *Festuca altaica* occurs in trace amounts.

Plate 43. Eluviated Eutric Brunisol. Site 235. Little soil development has taken place since the ash was deposited. Horizons are as follows:
LF, 3 - 0 cm..
C(Ash), 0 - 6 cm., 10YR 7/2, loamy sand, plentiful very fine and fine roots.
AH, 6 - 7 cm., 10YR 2/1, loamy sand, plentiful very fine and fine roots, subangular and subround gravel.
Ae, 7 - 17 cm., 10YR 5/2, loamy sand, few very fine and fine roots, subangular and subrounded gravel.
Bm, 17 - 27 cm., 10YR 5/8, loamy sand, few very fine and fine roots, subangular and subrounded gravel.
BC, 27 - 50 cm., 10YR 5/6, loamy sand.

Plate 44. SASP/CAAQ CT, Site 234, 1250 m. A hygric fen community dominated by *Carex aquatilis* (70% cover). Shrubs present are *Salix* sp. (20% cover), *Potentilla fruticosa* (4% cover) and *Betula glandulosa* (<1% cover).

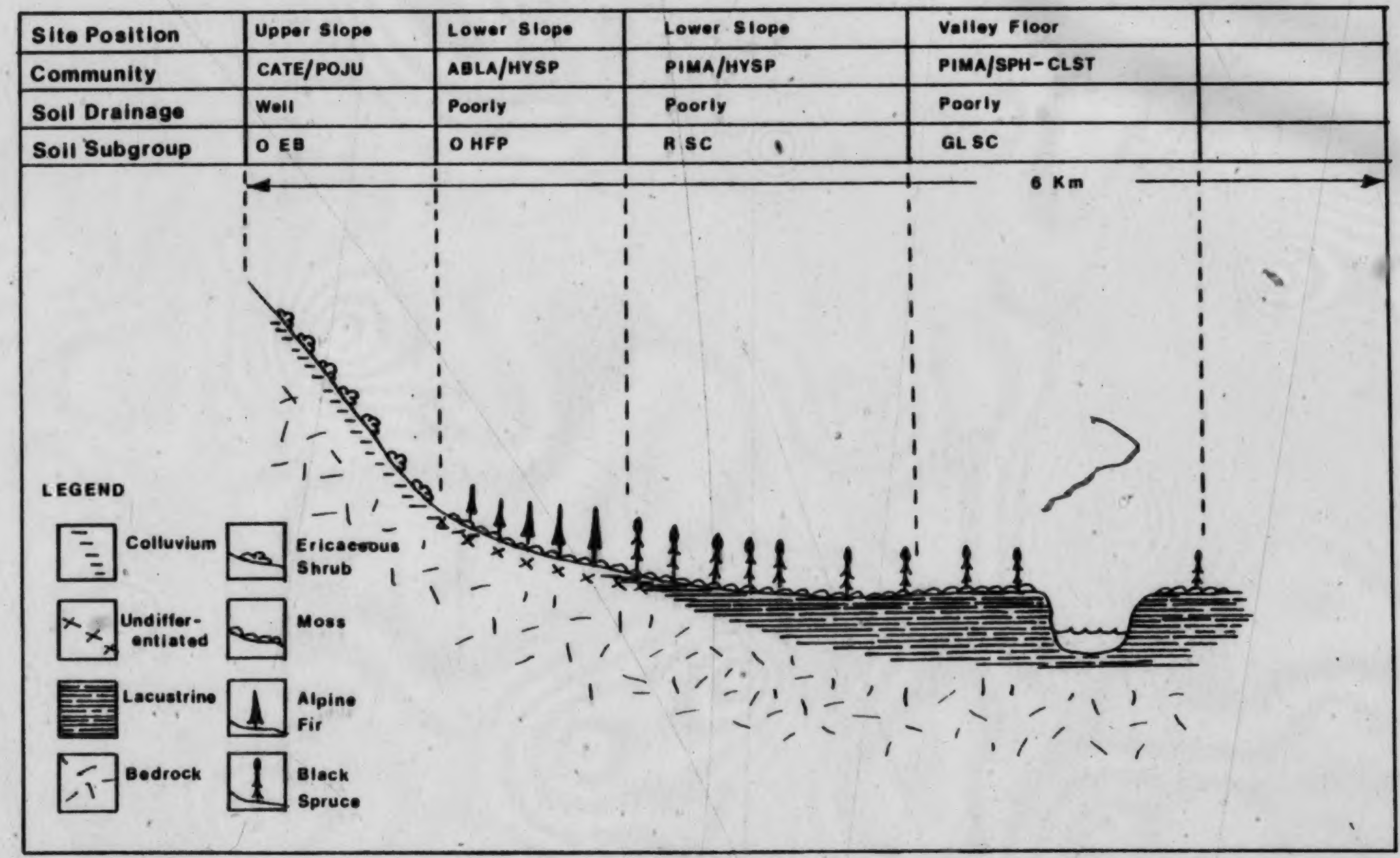
Plate 45. Rego Gleysol, Site 234. Horizon order is as follows:
OM, 18 - 0 cm. Abundant fine and very fine roots.
C, 0 - 26 cm., 10YR 8/2, loam, plentiful fine and very fine roots.
Cg, 26 - 36 cm., 10YR 4/1, 7.5YR 4/6, silty clay loam.



Site Position	Upper Slope	Mid Slope	Valley Floor
Community	CATE/DISP-POJU	ABLA/HYSP	SASP/HYSP
Soil Drainage	Well	Well	Poorly
Soil Subgroup	O DYB		R G

3 Km
LEGEND
Alluvium
Morainal
Colluvium
Bedrock
Ericaceous Shrub
Moss
Alpine Fir Krummholz
Willow

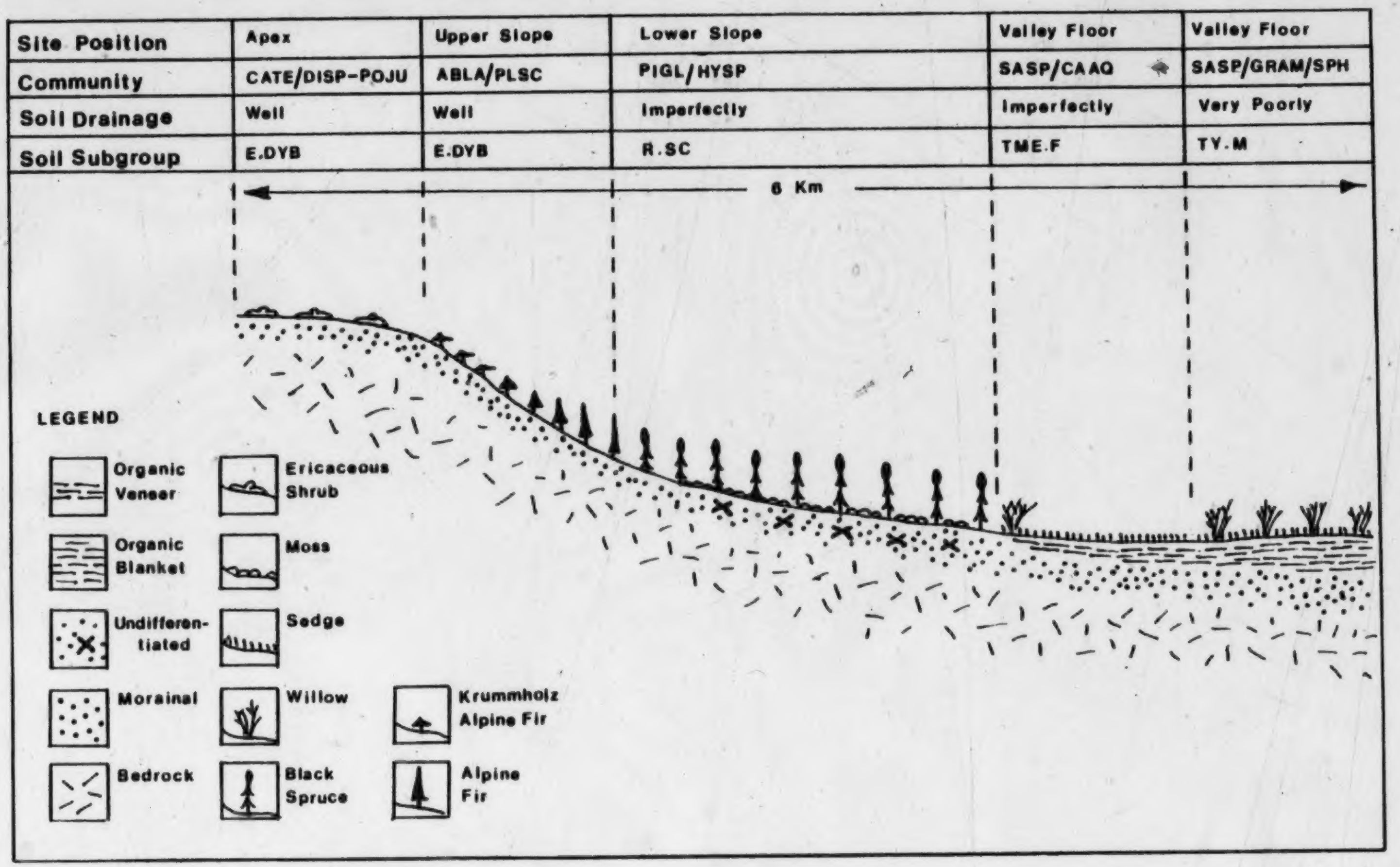
Figure 21. Cross-sectional representation of a north-facing alpine/subalpine slope - Keele Peak, (63° 23' N, 130° 30' W) based on three sites sampled along a foot traverse. Elevation ranges from 1430 - 1680 m. The ABLA/HYSP site is pictured in Plate 12.



Site Position	Upper Slope	Lower Slope	Lower Slope	Valley Floor	
Community	CATE/POJU	ABLA/HYSP	PIMA/HYSP	PIMA/SPH-CLST	
Soil Drainage	Well	Poorly	Poorly	Poorly	
Soil Subgroup	O EB	O HFP	R SC	GL SC	

6 Km
LEGEND
Colluvium
Undifferentiated
Lacustrine
Bedrock
Ericaceous Shrub
Moss
Alpine Fir
Black Spruce

Figure 22. Composite Cross-sectional representation of a north-facing slope along the Hess River based on 4 sites. Elevation ranges from 990 m to 1440 m.



Site Position	Apex	Upper Slope	Lower Slope	Valley Floor	Valley Floor
Community	CATE/DISP-POJU	ABLA/PLSC	PIGL/HYSP	SASP/CAAQ	SASP/GRAM/SPH
Soil Drainage	Well	Well	Imperfectly	Imperfectly	Very Poorly
Soil Subgroup	E.DYB	E.DYB	R.SC	TME.F	TY.M

6 Km
LEGEND
Organic Veneer
Organic Blanket
Undifferentiated
Morainal
Bedrock
Ericaceous Shrub
Moss
Sedge
Willow
Black Spruce
Krummholz Alpine Fir
Alpine Fir

Figure 23. Cross-sectional representation of a south-facing slope north of the Ross River in the Pelly Plateau physiographic region (62° 50' N, 130° 35' W), based on 5 sites sampled along a foot traverse. Elevational range is from 1180 to 1470 m. Note that the PIGL/HYSP site is dominated by *Picea mariana* , but is clustered with the PIGL stands due to the similarity of understory species.

8.4 Data Analysis Methods

Before data analysis could proceed, the data were keypunched directly from the field forms. The forms used in the study had been designed by the biophysical inventory staff. The form design was to have been such that 1) the field forms were easy to use in the field, 2) data keypunching could proceed quickly and easily, and 3) that the input data were in a useable format. It was hoped that other researchers working in the Yukon would use the forms so that data was collected in a consistent and comparable manner. Unfortunately a biostatistician was not consulted during the design of the forms or during the formatting for keypunching. While the forms were easy to use in the field, the keypunchers found them very difficult to work with, and consequently took 6 months to enter the data. Another three months were required to reformat and visually edit the data. The use of the field forms used in this study is not recommended if one wishes to enter data directly into a computer from the forms. However, if the forms are used and computer entry is desired, it is strongly recommended that the user format the data to meet his specific needs rather than use the input format specified by McKenna and Davies (1983).

Initially several clustering techniques were used including: 1) COMPCLUS a nonhierarchical clustering technique designed for rapid, intitial clustering of large data sets (Gauch 1979); 2)TWINSPAN, (two-way indicator species analysis) a divisive, hierarchical clustering technique, based on reciprocal averaging (Hill 1979b); 3) minimum variance cluster analysis, an agglomerative hierarchical technique, with standardized and non-standardized (raw) species cover values as the data base for a Euclidean distance matrix; and 4) complete-linkage cluster analysis, an agglomerative heirarchical technique, using non-standardized species cover values as the data base for a similarity matrix.

TWINSPAN was the initial clustering technique used. It was chosen because it is a divisive hierarchical technique which as an advantage over agglomerative techniques in that it uses all available information at the initial stage (Williams 1971). It begins with all samples together in a single cluster and successively divides the samples into a hierarchy of smaller and smaller clusters (Gauch 1982).

TWINSPAN was rejected as a suitable clustering program for the following reasons: 1) the large data set resulted in difficulties in assimilating the information in the output, 2) it did not appear to give ecologically meaningful groupings, and 3) the resulting clusters are not arranged into a dendrogram, making comparisons between successive runs which used different input parameters very tedious and time-consuming, especially when working with a large data set.

Because of the problems of assimilation resulting from a large data set, and because many clustering programs cannot handle large data sets, COMPCLUS was used in an attempt to divide the data into manageable subsets to be used in further analysis. Several problems were encountered. It is necessary to decide the number of clusters desired in the output before the analysis, which requires a good intuitive understanding of the data set properties. As with TWINSPAN it was difficult to assimilate the information in the output and to compare output from different runs. As COMPCLUS starts clustering by picking a sample at random, and clusters samples within a user-specified radius of that sample, the use of different randon numbers results in differing classifications. Because of the sequence in which cluster centers are selected samples may be misclassified, being closer to the center of an adjacent cluster than to the center of its own cluster. There is no method of identifying misclassified samples.

Despite these problems, the results from COMPCLUS appeared to be reasonable. However , it was difficult to ascertain which runs gave better results, and whether more or less clusters would be more appropriate. Also the output resulted in composite stands that subsequently could be analyzed using other CEP programs. However the output was not such that the stands within these composite clusters could be further analyzed.

Therefore, COMPCLUS was abandoned and the data set was divided into the three ecologically useful subsets of forested, non-forested below-treeline , and alpine-nonforested subalpine sites, to be analyzed using the methods available in the Clustan 1C suite of computer programs (Wishart 1978).

Two hierarchical, agglomerative clustering techniques were attempted: 1) minimum variance cluster analysis with standardized and nonstandardized (raw) species cover values as the data base for a Euclidean distance (dissimilarity) matrix; and 2) complete-linkage cluster analysis using nonstandardized species cover values as the data base of a similarity matrix calculated by a numerical equivalent of Jaccard's coefficient of similarity (Wishart 1975).

Standardization of the data, a procedure often recommended (Wishart 1975, Gauch 1982), resulted in an unacceptable amount of chaining with the clusters and was abandoned. Minimum variance cluster analysis with raw data gave similar, but not as ecologically meaningful clusters as those resulting from complete-linkage cluster analysis, which was deemed to be the more suitable clustering technique. The suitability of the two clustering techniques was assessed by visually examining the sites grouped into clusters, and by plotting the clusters, in the form of rectangles on the DECORANA site-ordination field. The clustering technique which produced the tightest groups (smallest rectangles) with the least amount of overlap on the ordination field was considered the best clustering technique. The poorer results of the minimum-variance cluster analysis were probably caused by the use of the Euclidean distance matrix, which clusters on the basis of dissimilarity, not similarity between stands. Both of the above clustering methods gave good results for the alpine / subalpine non-treed zone; however, complete-linkage cluster analysis was used in order to be consistent.

9. SUMMARY and CONCLUSIONS

This study was conducted in the Macmillan Pass/Sheldon Lakes area of the east-central Yukon Territory as part of a larger biophysical mapping project carried out by the Yukon Department of Renewable Resources in response to proposed mineral development in the area. The main purpose of this thesis has been to classify the vegetation of the area, and to elucidate relationships between the vegetation and environmental factors.

Sampling sites were selected 1) after reconnaissance traverses were flown over the area, and 2) initial vegetation communities were identified along the traverses on already delineated 1:74,000 black and white aerial photographs. At each sampling site, all species were listed and percent cover was estimated. A soil pit was dug, the soil was identified to the subgroup level, and soil samples were collected for analysis. Site information was collected.

Vegetation units (syntaxa) were generated using complete-linkage cluster analysis (CLUSTAN). Plots and species were ordinated using detrended correspondence analysis (DECORANA).

Based on information collected from 454 plots, a total of 28 community types and 42 tentative community types were recognized: 9 CT's and 21 TCT's in the alpine/nonforested subalpine zone; 12 CT's and 9 TCT's in the forest zone; and 7 CT's and 12 TCT's in the below-treeline, non-forested zone.

The alpine-subalpine zone was the most heterogeneous with 208 species occurring in 104 plots. The major vegetation community types can be summarized by grouping the communities into broad physiognomic groups based on growth-form. These groups are as follows: subalpine shrub, lichen heath, moss heath, moist forb-graminoid tundra, graminoid moss tundra and wetland communities.

The forest communities were more homogeneous, with 133 species occurring in 246 plots. Community types were differentiated more on the relative abundance of the same species rather than on different species. The vegetation of the zone can be summarized by grouping the communities into broad vegetation community types, the important ones being: white spruce/feathermoss, subalpine fir/feathermoss, black spruce/feathermoss, black spruce/sphagnum, conifer/lichen-feathermoss and successional burn types.

The below treeline, non-forested zone, which had 153 species in 102 plots, consisted of two major ecological groupings: submesic lichen shrublands, and fen wetlands. Occasionally, graminoid meadows similar to those found in the subalpine occur here.

Based on the DECORANA ordination and subsequent correlations of environmental factors with the position of plots on the ordination axes, the study generated a number of hypotheses concerning relationships between community types, species distribution and environmental factors. Selected hypotheses are listed below.

1. Soil pH, nutrient status and elevation are the major environmental factors controlling the distribution of communities and species in the forest zone.
2. Moisture and, possibly, snow depth are the controlling environmental factors in the alpine-non-forested subalpine zone.
3. Soil drainage and nutrient status are the factors controlling species distribution in the fen communities.

The DECORANA ordination proved to be a very useful tool for elucidating the relationships between communities and their environments. In some instances it was necessary to do an ordination, remove the obvious outliers, as suggested by Gauch (1982), and then re-ordinate the data set to obtain satisfactory results.

It is notable that within the forest zone, sites that had been burned did not occur as outliers on the ordination field, but fell within the boundaries of the stable community types which , based on environmental factors and species composition, will most likely succeed them. There are vast tracts of burned land within the Yukon where the original community is not known. Ordination of burned and adjacent unburned communities could be a useful tool in predicting the successional trends and climax communities on these burned lands.

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Appendix I. Soil Subgroups found in Study Area

Soil nomenclature follows the Canadian System of Soil Classification, Canadian Soil Survey Committee, Subcommittee on Soil Classification, 1978.

Appendix I. Soil Subgroups

Name	Abbreviation
Orthic Melanic Brunisol	O.MB
Orthic Eutric Brunisol	O.EB
Eluviated Eutric Brunisol	E.EB
Orthic Dystric Brunisol	O.DYB
Eluviated Dystric Brunisol	E.DYB
Gleyed Dystric Brunisol	GL.DYB
Orthic Turbic Cryosol	O.TC
Regosolic Turbic Cryosol	R.TC
Gleysolic Turbic Cryosol	GL.TC
Orthic Static Cryosol	O.SC
Brunisolic Static Cryosol	BR.SC
Regosolic Static Cryosol	R.SC
Gleysolic Static Cryosol	GL.SC
Fibric Organic Cryosol	FI.OC
Humic Organic Cryosol	HU.OC
Terric Mesic Organic Cryosol	TME.OC
Terric Fibric Organic Cryosol	TFI.OC
Rego Humic Gleysol	R.HG
Orthic Gleysol	O.G
Rego Gleysol	R.G
Terric Fibrisol	T.F
Mesic Fibrisol	ME.F
Cumulo Fibrisol	CU.F
Typic Mesisol	TY.M
Terric Mesic Fibrisol	TME.F
Typic Mesisol	TY.M
Cumulo Mesisol	CU.M
Terric Mesisol	T.M
Cumulo Humisol	CU.H
Orthic Ferro-Humic Podzol	O.FHP
Orthic Humo-Ferric Podzol	O.HFP
Orthic Regosol	O.R
Cumulic Regosol	CU.R
Orthic Humic Regosol	O.HR

Appendix II. Data Summaries from Three Meterological Stations

Ross River is located southwest of the study area, Sheldon Lake is located in the southwest of the study area, and Tsichu River is located east of the study area, on the NWT side of the continental divide.

Data are from Wahl, H., Climate of the Yukon, unpublished draft manuscript, Department of the Environment, Whitehorse, Yukon.

Appendix II
ROSS RIVER YUKON
Lat 61°58'N, Long 132°26'W, Elevation 689 m

1959-1978 calc.

TEMPERATURES	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	**YEAR**
Mean Daily Max.	-23.2	-10.8	-2.8	6.2	12.9	20.2	21.4	19.2	12.5	3.4	-10.9	18.5	2.5
Mean Daily Min.	-35.4	-28.3	-22.8	-9.3	-2.7	2.1	4.8	2.2	-2.1	-10.1	-23.9	-30.8	-5.3
Mean Daily	-29.3	-19.6	-12.8	-1.6	5.1	11.2	13.1	10.7	5.2	-3.4	-17.4	-24.7	-5.3
Extreme Max.	5.6	11.7	11.7	21.1	26.7	33.3	31.0	31.1	27.8	18.9	11.7	5.6	33.3
Year/Date	22/76	28/68	28/62	29/76	29/6	13/69	10/78	1/71	1/74	1/75	1/69	19/56	
No. of Years of Record	12	13	12	13	14	12	13	13	12	13	13	14	
Extreme Min.	-59.4	-59.4	-49.4	-35.0	-11.7	-6.7	-3.3	-5.6	-18.3	-28.9	-48.3	-57.6	-59.4
Year/Date	9/75	3/68	8/72	2/79	1/78	3/72	30/75	11/69	29/74	28/75	18/69	6/75	
No. of Years On Record	12	13	13	12	13	12	13	13	12	13	13	14	
PRECIPITATION													
Mean Rainfall	NIL	NIL	NIL	6.1	13.4	38.7	45.5	29.3	20.8	3.5	0.2	NIL	157.5
Mean Snowfall	21.0	15.8	8.1	5.0	0.4	NIL	NIL	1.0	0.8	14.8	23.4	19.7	110.0
Mean Total ppt.	21.0	15.8	8.1	11.1	13.8	38.7	45.5	30.3	21.6	18.3	23.6	19.7	267.5
No. of Days of Msrbl ppt.	9	5	4	3	5	8	13	11	10	7	10	9	94
Mean Month End Depth Of Snow on Ground	34	39	30	TR	NIL	NIL	NIL	NIL	NIL	TR	18	28	
Max. ppt.	30.2	22.1	27.4	41.4	32.5	54.1	90.7	58.7	52.6	33.0	31.0	39.6	
Year	77	72	72	71	74	68	68	69	72	71	69	79	
Min. ppt.	8.4	3.0	0.8	1.0	5.1	9.9	12.4	12.4	3.6	1.0	5.1	6.6	
Year	69	75	70	73	70	72	71	70	76	79	74	69	

Appendix II
SHELDON LAKE, YUKON
Lat 62°37'N, Long 131°17'W, Elevation 884 m

1959-1978 calc.

TEMPERATURES	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	**YEAR**
Mean Daily Max.					11.3	18.0	20.0	17.5	10.6				
Mean Daily Min.					-3.6	1.9	3.9	1.1	-3.0				
Mean Daily					3.9	9.9	12.0	9.3	3.8				
Extreme Max.					21.1	27.2	30.6	30.6	26.7				
Year/Date					28/77	28/76	30/76	1/76	1/75				
No. of Years of Record					7	9	9	9	9				
Extreme Min.					-17.8	-5.0	-2.8	-10.0	-21.7				
Year/Date					5/71	30/77	30/75	29/70	30/74				
No. of Years On Record					7	9	9	9	9				
PRECIPITATION													
Mean Rainfall					19.3	48.8	60.2	60.2	31.3				
Mean Snowfall					3.8	TR	NIL	TR	2.4				
Mean Total Pcpn.					23.1	48.8	60.2	60.2	33.7				
No. of Days of Msrbl ppt.					8	12	11	12	11				
Mean Month End Depth Of Snow on Ground													
Max. ppt.					46.7	81.0	111.2	184.7	46.1				
Year					77	72	78	70	77				
Min. ppt.					5.1	10.4	25.4	20.3	5.6				
Year					79	75	71	79	74				

Appendix II
TSICHU RIVER, N.W.T.
Lat 63°18'N, Long 129°49'W, Elevation 689 m

1959-1978 calc.

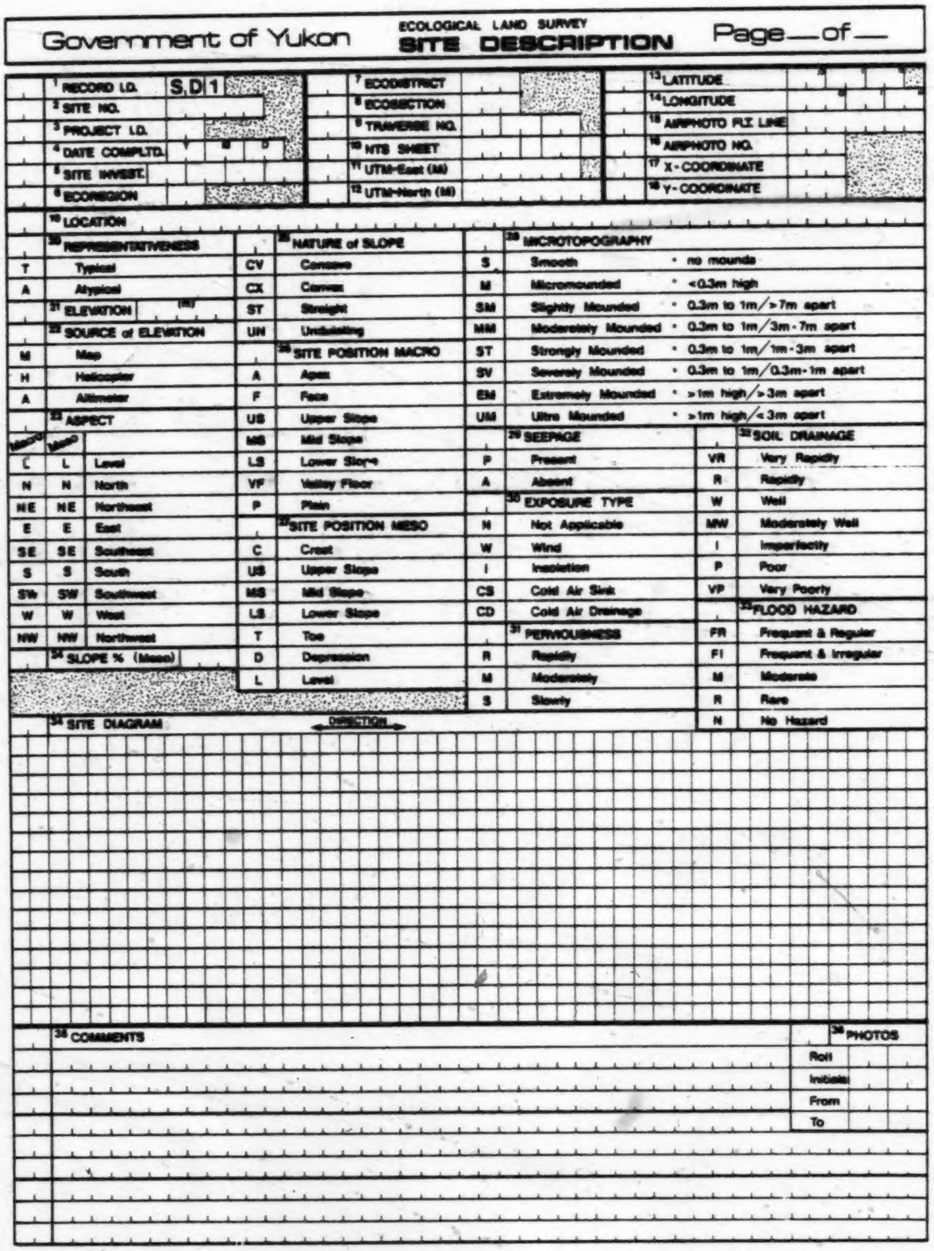
TEMPERATURES	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	**YEAR**
Mean Daily Max.	-18.6	-14.8	-12.9	-2.0	6.0	14.9	17.0	14.3	7.3	-2.3	-11.3	-17.5	-1.7
Mean Daily Min.	-29.5	-26.9	-26.7	-16.1	-4.9	0.9	2.9	1.0	-2.9	-12.2	-23.0	-28.2	-13.8
Mean Daily	-24.1	-20.9	-19.8	-9.1	0.6	7.9	10.0	7.7	2.2	-7.3	-17.1	-22.9	-7.7
Extreme Max.	-0.6	2.2	2.5	8.3	17.2	25.0	27.2	25.0	19.4	5.6	5.6	0.0	27.2
Year/Date	5/77	1/77	22/79	29/77	29/77	30/75	10/75	2.78	21/76	7/76	3/74	1/76	
No. of Years of Record	5	5	5	5	5	5	4	4	5	6	6	6	
Extreme Min.	-51.1	-51.0	-41.7	-37.0	-18.9	-8.9	-5.0	-10.6	-12.2	-35.6	-44.4	-50.6	-51.1
Year/Date	8/75	13/79	23/77	4/79	11/78	12/75	13/77	30/77	3/77	31/75	2/75	7/75	
No. of Years On Record	5	5	5	5	5	5	4	4	5	6	6	5	
PRECIPITATION													
Mean Rainfall	NIL	0.7	0.4	TR	20.0	42.8	53.9	55.5	33.5	1.1	0.4	NIL	208.3
Mean Snowfall	40.0	21.1	29.3	35.0	15.0	0.9	0.9	0.8	18.7	54.6	44.6	40.3	301.6
Mean Total ppt.	39.8	21.8	28.9	35.0	35.0	43.7	54.8	56.3	52.2	55.7	45.0	40.3	508.5
No. of Days of Msrbl ppt.	12	10	12	12	9	14	15	14	15	15	14	13	155
Mean Month End Depth Of Snow on Ground	69	72	72	79	10	NIL	NIL	NIL	NIL	35	43	59	
Max. ppt.	66.9	25.9	42.9	46.0	43.6	56.9	59.9	77.2	77.0	143.0	55.4	62.5	
Year	76	77	76	77	78	78	79	77	75	78	77	74	
Min. ppt.	7.0	3.9	14.0	9.4	7.1	19.8	41.4	52.6	25.1	30.7	32.9	25.9	
Year	79	79	75	79	76	75	78	79	78	76	79	76	

Appendix III. Field Forms

The following forms were designed by the Resource Inventory staff, Yukon Department of Renewable Resources, 1982. For a discussion on their use see 8.4 Data Analysis Methods.

Appendix III

Site Description



Government of Yukon

ECOLOGICAL LAND SURVEY

SITE DESCRIPTION

Page — of —

1 RECORD I.D. S,D 1
2 SITE NO.
3 PROJECT I.D.
4 DATE COMPLTD. Y M D
5 SITE INVEST.
6 ECOREGION
7 ECODISTRICT
8 ECOSECTION
9 TRAVERSE NO.
10 NTS SHEET
11 UTM-East (M)
12 UTM-North (M)
13 LATITUDE
14 LONGITUDE
15 AIRPHOTO FLT. LINE
16 AIRPHOTO NO.
17 X-COORDINATE
18 Y-COORDINATE
19 LOCATION

20 REPRESENTATIVENESS

T	Typical
A	Atypical

21 ELEVATION (m)

22 SOURCE of ELEVATION

M	Map
H	Helicopter
A	Altimeter

23 ASPECT

Macro	Meso	
L	L	Level
N	N	North
NE	NE	Northeast
E	E	East
SE	SE	Southeast
S	S	South
SW	SW	Southwest
W	W	West
NW	NW	Northwest

24 SLOPE % (Meso)

25 NATURE of SLOPE

CV	Concave
CX	Convex
ST	Straight
UN	Undulating

26 SITE POSITION MACRO

A	Apex
F	Face
US	Upper Slope
MS	Mid Slope
LS	Lower Slope
VF	Valley Floor
P	Plain

27 SITE POSITION MESO

C	Crest
US	Upper Slope
MS	Mid Slope
LS	Lower Slope
T	Toe
D	Depression
L	Level

28 MICROTOPOGRAPHY

S	Smooth	• no mounds
M	Micromounded	• <0.3m high
SM	Slightly Mounded	• 0.3m to 1m/>7m apart
MM	Moderately Mounded	• 0.3m to 1m/3m-7m apart
ST	Strongly Mounded	• 0.3m to 1m/1m-3m apart
SV	Severely Mounded	• 0.3m to 1m/0.3m-1m apart
EM	Extremely Mounded	• >1m high/>3m apart
UM	Ultra Mounded	• >1m high/<3m apart

29 SEEPAGE

P	Present
A	Absent

30 EXPOSURE TYPE

N	Not Applicable
W	Wind
I	Insolation
CS	Cold Air Sink
CD	Cold Air Drainage

31 PERVIOUSNESS

R	Rapidly
M	Moderately
S	Slowly

32 SOIL DRAINAGE

VR	Very Rapidly
R	Rapidly
W	Well
MW	Moderately Well
I	Imperfectly
P	Poor
VP	Very Poorly

33 FLOOD HAZARD

FR	Frequent & Regular
FI	Frequent & Irregular
M	Moderate
R	Rare
N	No Hazard

34 SITE DIAGRAM

DIRECTION

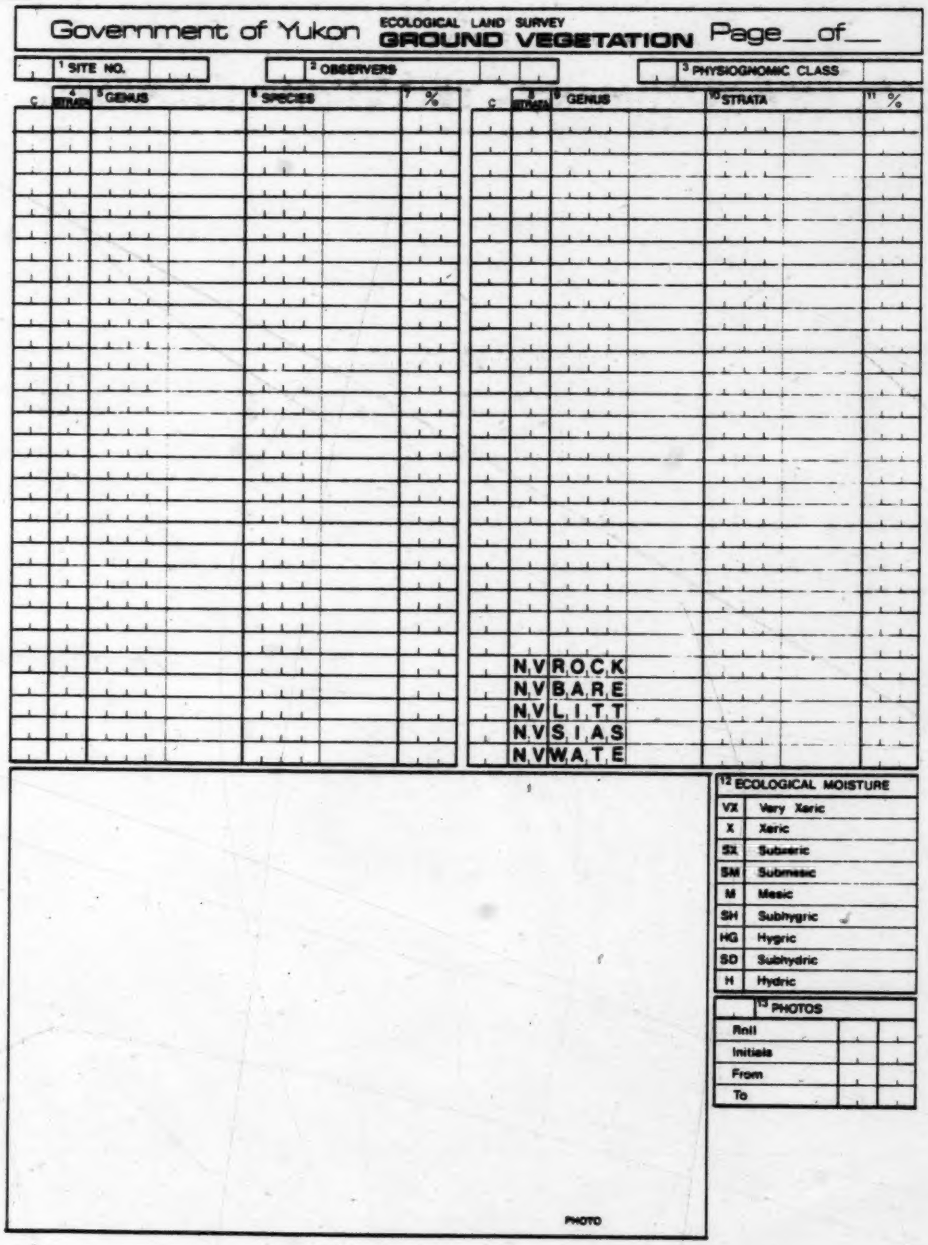
35 COMMENTS

36 PHOTOS

Roll
Initials
From
To

Appendix III

Vegetation Description



Government of Yukon ECOLOGICAL LAND SURVEY **GROUND VEGETATION** Page__of__

1 SITE NO.

2 OBSERVERS

3 PHYSIOGNOMIC CLASS

C	4 STRATA	5 GENUS	6 SPECIES	7 %

C	8 STRATA	9 GENUS	10 STRATA	11 %
	NV	ROCK		
	NV	BARE		
	NV	LITT		
	NV	SIAS		
	NV	WATE		

12 ECOLOGICAL MOISTURE	
VX	Very Xeric
X	Xeric
SX	Subxeric
SM	Submesic
M	Mesic
SH	Subhygric
HG	Hygric
SD	Subhydric
H	Hydric

13 PHOTOS		
Roll		
Initials		
From		
To		

PHOTO

Vegetation Description continued

Government of Yukon ECOLOGICAL LAND SURVEY **GROUND VEGETATION** Page__of__

22 SITE NO.

	14 TREE TALLY	15	16	17	18	19 PRISM	20	21
	TREE NO.	GENUS	Spp	DBH (cm)	Ht (m)	AGE	HL 2cm	Crown Class

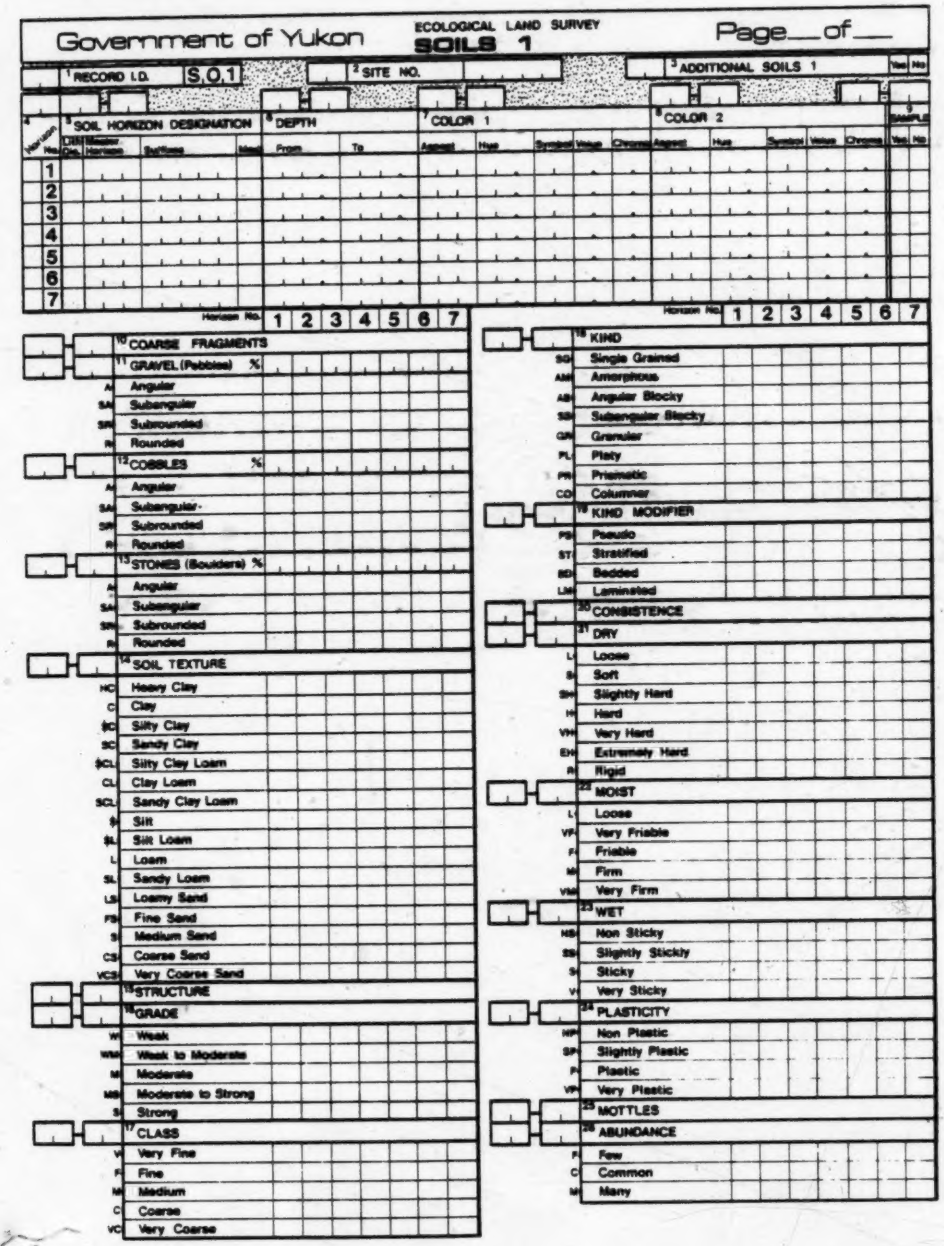
TT	TREES > 5m
LT	TREES < 5m
TS	SHRUBS 1.5 - 5.0m
MS	SHRUBS 0.5 - 1.5m
LS	SHRUBS 0.1 - 0.5m
GS	GROUND SHRUBS < 0.1m
Fb	FORBS
Gr	GRAMINOIDS
Br	BRYOPHYTES
Ln	LICHENS
NV	NON-VEGETATED

23 COMMENTS

PHOTO

Appendix III

Soil Description



Government of Yukon ECOLOGICAL LAND SURVEY **SOILS 1** Page__of__

1 RECORD I.D. S,O,1

2 SITE NO.

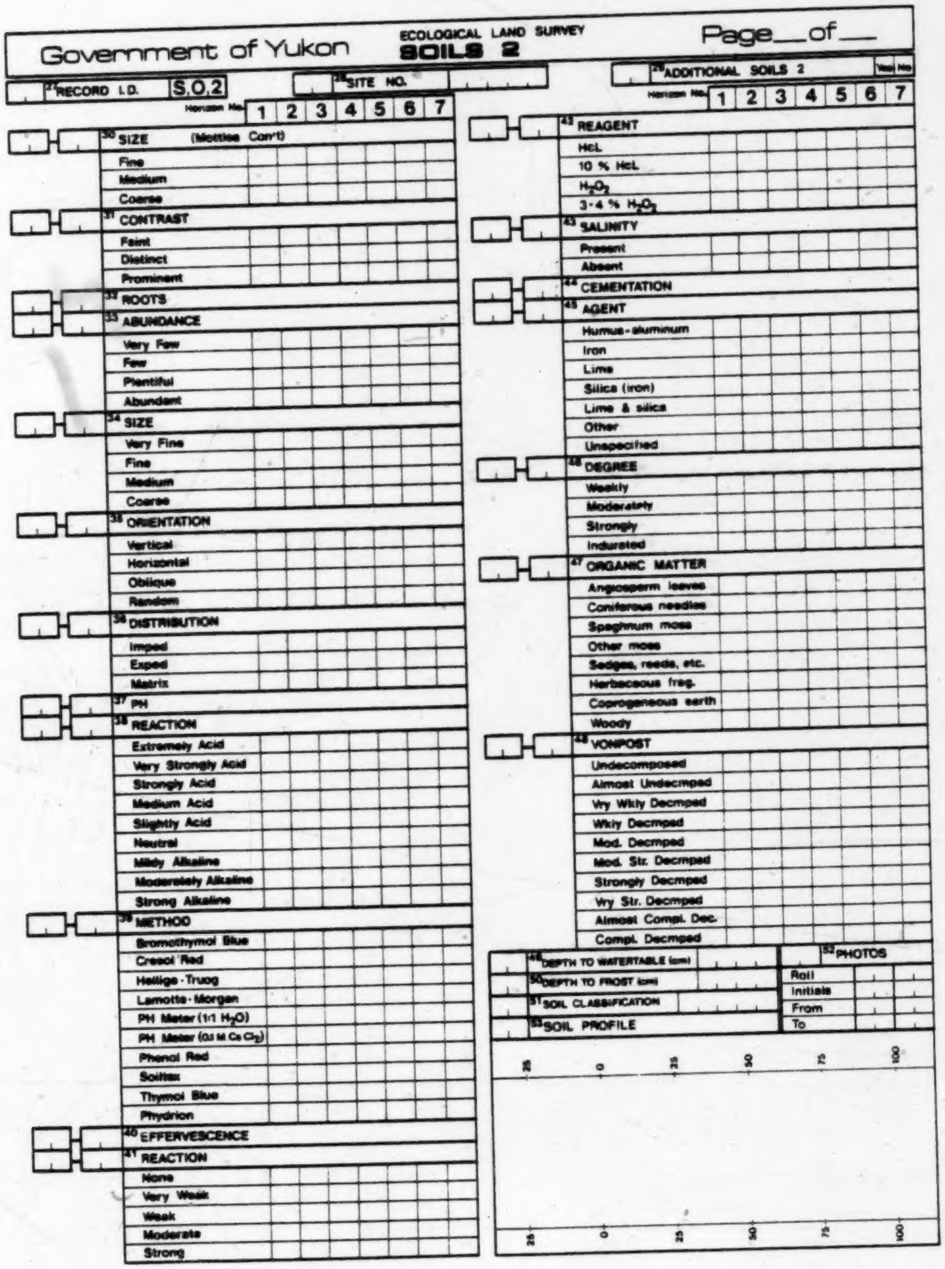
3 ADDITIONAL SOILS 1 Yes No

4 Horizon No.	5 SOIL HORIZON DESIGNATION Lith Dis.	Master Horizon	Suffixes	Mod.	6 DEPTH From	To	7 COLOR 1 Aspect	Hue	Symbol	Value	Chroma	8 COLOR 2 Aspect	Hue	Symbol	Value	Chroma	9 SAMPLE Yes	No
1																		
2																		
3																		
4																		
5																		
6																		
7																		

	Horizon No.	1	2	3	4	5	6	7
	10 COARSE FRAGMENTS							
	11 GRAVEL (Pebbles) %							
A	Angular							
SA	Subangular							
SR	Subrounded							
R	Rounded							
	12 COBBLES %							
A	Angular							
SA	Subangular							
SR	Subrounded							
R	Rounded							
	13 STONES (Boulders) %							
A	Angular							
SA	Subangular							
SR	Subrounded							
R	Rounded							
	14 SOIL TEXTURE							
HC	Heavy Clay							
C	Clay							
SiC	Silty Clay							
SC	Sandy Clay							
SiCL	Silty Clay Loam							
CL	Clay Loam							
SCL	Sandy Clay Loam							
Si	Silt							
SiL	Silt Loam							
L	Loam							
SL	Sandy Loam							
LS	Loamy Sand							
FS	Fine Sand							
S	Medium Sand							
CS	Coarse Sand							
VCS	Very Coarse Sand							
	15 STRUCTURE							
	16 GRADE							
W	Weak							
WM	Weak to Moderate							
M	Moderate							
MS	Moderate to Strong							
S	Strong							
	17 CLASS							
V	Very Fine							
F	Fine							
M	Medium							
C	Coarse							
VC	Very Coarse							

	Horizon No.	1	2	3	4	5	6	7
	18 KIND							
SG	Single Grained							
AM	Amorphous							
AB	Angular Blocky							
SB	Subangular Blocky							
GR	Granular							
PL	Platy							
PR	Prismatic							
CO	Columnar							
	19 KIND MODIFIER							
PS	Pseudo							
ST	Stratified							
BD	Bedded							
LM	Laminated							
	20 CONSISTENCE							
	21 DRY							
L	Loose							
S	Soft							
SH	Slightly Hard							
H	Hard							
VH	Very Hard							
EH	Extremely Hard							
R	Rigid							
	22 MOIST							
L	Loose							
VF	Very Friable							
F	Friable							
M	Firm							
VM	Very Firm							
	23 WET							
NS	Non Sticky							
SS	Slightly Stickly							
S	Sticky							
V	Very Sticky							
	24 PLASTICITY							
NP	Non Plastic							
SP	Slightly Plastic							
P	Plastic							
VP	Very Plastic							
	25 MOTTLES							
	26 ABUNDANCE							
F	Few							
C	Common							
M	Many							

Soil Description continued



Government of Yukon

ECOLOGICAL LAND SURVEY

SOILS 2

Page__of__

27 RECORD I.D. S,O,2

28 SITE NO.

29 ADDITIONAL SOILS 2 Yes No

Horizon No.	1	2	3	4	5	6	7
30 SIZE (Mottles Con't)							
Fine							
Medium							
Coarse							
31 CONTRAST							
Faint							
Distinct							
Prominent							
32 ROOTS							
33 ABUNDANCE							
Very Few							
Few							
Plentiful							
Abundant							
34 SIZE							
Very Fine							
Fine							
Medium							
Coarse							
35 ORIENTATION							
Vertical							
Horizontal							
Oblique							
Random							
36 DISTRIBUTION							
Imped							
Exped							
Matrix							
37 PH							
38 REACTION							
Extremely Acid							
Very Strongly Acid							
Strongly Acid							
Medium Acid							
Slightly Acid							
Neutral							
Mildy Alkaline							
Moderately Alkaline							
Strong Alkaline							
39 METHOD							
Bromothymol Blue							
Cresol Red							
Hellige - Truog							
Lamotte - Morgan							
PH Meter (1:1 H_2O)							
PH Meter (0.1 M $CaCl_2$)							
Phenol Red							
Soiltex							
Thymol Blue							
Phydrion							
40 EFFERVESCENCE							
41 REACTION							
None							
Very Weak							
Weak							
Moderate							
Strong							

Horizon No.	1	2	3	4	5	6	7
42 REAGENT							
HcL							
10 % HcL							
H_2O_2							
3-4 % H_2O_2							
43 SALINITY							
Present							
Absent							
44 CEMENTATION							
45 AGENT							
Humus - aluminum							
Iron							
Lime							
Silica (iron)							
Lime & silica							
Other							
Unspecified							
46 DEGREE							
Weakly							
Moderately							
Strongly							
Indurated							
47 ORGANIC MATTER							
Angiosperm leaves							
Coniferous needles							
Spaghnum moss							
Other moss							
Sedges, reeds, etc.							
Herbaceous frag.							
Coprogeneous earth							
Woody							
48 VONPOST							
Undecomposed							
Almost Undecmped							
Vry Wkly Decmped							
Wkly Decmped							
Mod. Decmped							
Mod. Str. Decmped							
Strongly Decmped							
Vry Str. Decmped							
Almost Compl. Dec.							
Compl. Decmped							

49 DEPTH TO WATERTABLE (cm)

50 DEPTH TO FROST (cm)

51 SOIL CLASSIFICATION

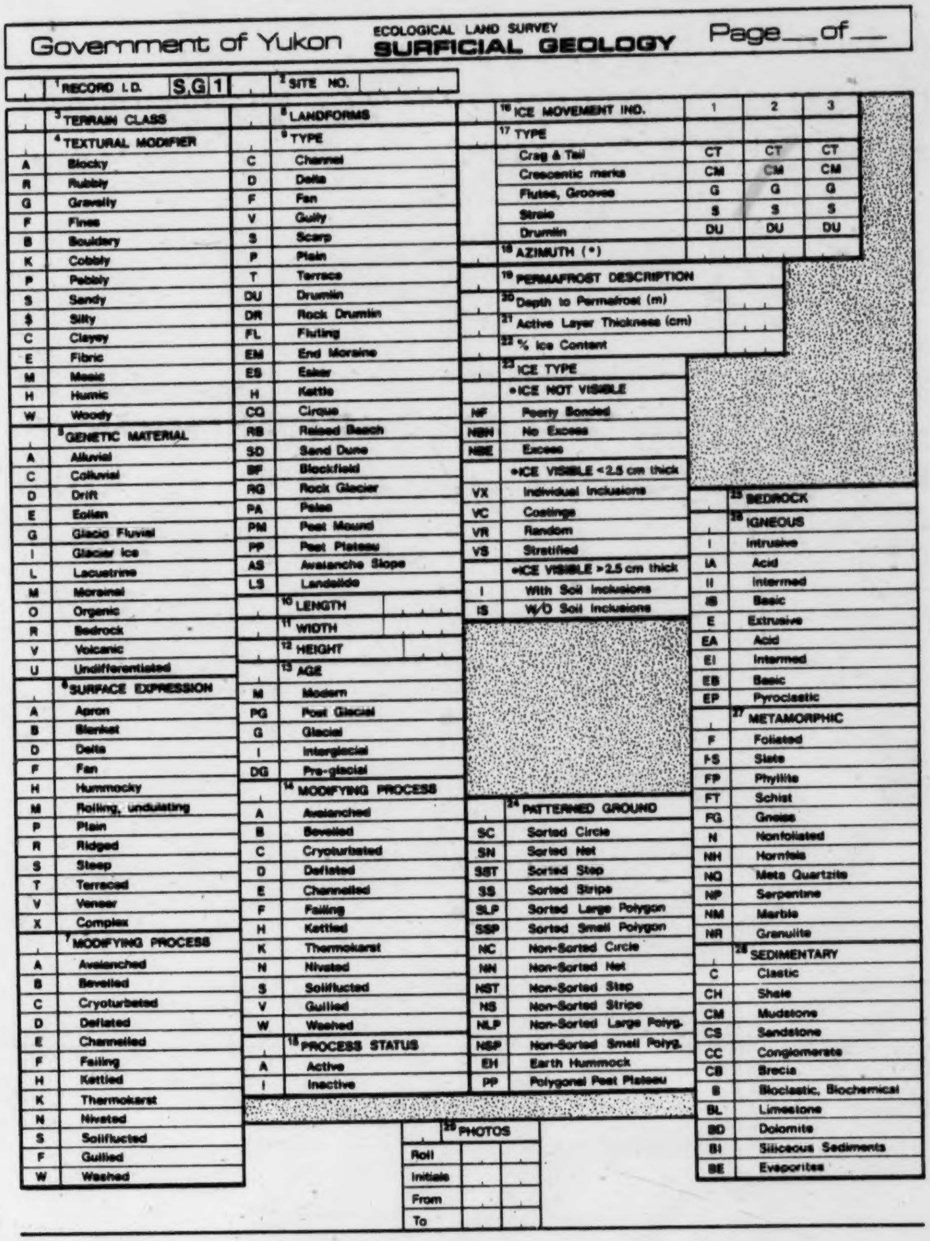
53 SOIL PROFILE

52 PHOTOS

Roll		
Initials		
From		
To		

Appendix III

Surficial Geology Description



Government of Yukon ECOLOGICAL LAND SURVEY **SURFICIAL GEOLOGY** Page__of__

1 RECORD I.D. S,G 1

2 SITE NO.

	3 TERRAIN CLASS
	4 TEXTURAL MODIFIER
A	Blocky
R	Rubbly
G	Gravelly
F	Fines
B	Bouldery
K	Cobbly
P	Pebbly
S	Sandy
$	Silty
C	Clayey
E	Fibric
M	Mesic
H	Humic
W	Woody
	5 GENETIC MATERIAL
A	Alluvial
C	Colluvial
D	Drift
E	Eolian
G	Glacio Fluvial
I	Glacier Ice
L	Lacustrine
M	Morainal
O	Organic
R	Bedrock
V	Volcanic
U	Undifferentiated
	6 SURFACE EXPRESSION
A	Apron
B	Blanket
D	Delta
F	Fan
H	Hummocky
M	Rolling, undulating
P	Plain
R	Ridged
S	Steep
T	Terraced
V	Veneer
X	Complex
	7 MODIFYING PROCESS
A	Avalanched
B	Bevelled
C	Cryoturbated
D	Deflated
E	Channelled
F	Failing
H	Kettled
K	Thermokarst
N	Nivated
S	Solifluctod
F	Gullied
W	Washed

	8 LANDFORMS
	9 TYPE
C	Channel
D	Delta
F	Fan
V	Gully
S	Scarp
P	Plain
T	Terrace
DU	Drumlin
DR	Rock Drumlin
FL	Fluting
EM	End Moraine
ES	Esker
H	Kettle
CQ	Cirque
RB	Raised Beach
SD	Sand Dune
BF	Blockfield
RG	Rock Glacier
PA	Palsa
PM	Peat Mound
PP	Peat Plateau
AS	Avalanche Slope
LS	Landslide
	10 LENGTH
	11 WIDTH
	12 HEIGHT
	13 AGE
M	Modern
PG	Post Glacial
G	Glacial
I	Interglacial
DG	Pre-glacial
	14 MODIFYING PROCESS
A	Avalanched
B	Bevelled
C	Cryoturbated
D	Deflated
E	Channelled
F	Failing
H	Kettled
K	Thermokarst
N	Nivated
S	Solifluctod
V	Gullied
W	Washed
	15 PROCESS STATUS
A	Active
I	Inactive

	16 ICE MOVEMENT IND.	1	2	3
	17 TYPE			
	Crag & Tail	CT	CT	CT
	Crescentic marks	CM	CM	CM
	Flutes, Grooves	G	G	G
	Striae	S	S	S
	Drumlin	DU	DU	DU
	18 AZIMUTH (°)			

	19 PERMAFROST DESCRIPTION	
	20 Depth to Permafrost (m)	
	21 Active Layer Thickness (cm)	
	22 % Ice Content	

	23 ICE TYPE
	•ICE NOT VISIBLE
NF	Poorly Bonded
NBN	No Excess
NBE	Excess
	•ICE VISIBLE <2.5 cm thick
VX	Individual Inclusions
VC	Coatings
VR	Random
VS	Stratified
	•ICE VISIBLE >2.5 cm thick
I	With Soil Inclusions
IS	W/O Soil Inclusions

	24 PATTERNED GROUND
SC	Sorted Circle
SN	Sorted Net
SST	Sorted Step
SS	Sorted Stripe
SLP	Sorted Large Polygon
SSP	Sorted Small Polygon
NC	Non-Sorted Circle
NN	Non-Sorted Net
NST	Non-Sorted Step
NS	Non-Sorted Stripe
NLP	Non-Sorted Large Polyg.
NSP	Non-Sorted Small Polyg.
EH	Earth Hummock
PP	Polygonal Peat Plateau

	25 BEDROCK
	26 IGNEOUS
I	Intrusive
IA	Acid
II	Intermed
IB	Basic
E	Extrusive
EA	Acid
EI	Intermed
EB	Basic
EP	Pyroclastic
	27 METAMORPHIC
F	Foliated
FS	Slate
FP	Phyllite
FT	Schist
FG	Gneiss
N	Nonfoliated
NH	Hornfels
NQ	Meta Quartzite
NP	Serpentine
NM	Marble
NR	Granulite
	28 SEDIMENTARY
C	Clastic
CH	Shale
CM	Mudstone
CS	Sandstone
CC	Conglomerate
CB	Brecia
B	Bioclastic, Biochemical
BL	Limestone
BD	Dolomite
BI	Siliceous Sediments
BE	Evaporites

	29 PHOTOS	
Roll		
Initials		
From		
To		

Appendix IV. Definitions of Soil Drainage, Soil Perviousness and Ecological Moisture Classes

Definitions are those of Walmsley, et. al., 1980.

Soil Drainage

1. **Rapidly drained** - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions. Soils are free from any evidence of gleying or mottling thoroughout the profile.

2. **Well drained** - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year. Soils are usually free from mottling in the upper 1 m, but may be mottled below this depth.

3. **Moderately-well drained** - The soil moisture in excess of field capacity remains for a small but significant part of the year. Soils are often faintly mottled in the lower B and C horizons or below a depth of 0.7 m.

4. **Imperfectly drained** - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are often distinctly mottled in the B and C horizons; the Ae horizon, if present, may by mottled. Soils are generally gleyed subgroups of of mineral soil orders.

5. **Poorly drained** - Soil moisture in excess of field capacity remains in all horizons for a large part of the year. Soils are strongly gleyed, prominent mottling may occur thoroughout. Soils are generally in the Gleysolic or Organic order.

6. **Very poorly drained** - Free water remains at or within 30 cm of the surface most of the year. The soils are usually strongly gleyed. Soil are generally in the Gleysolic or Organic order.

Soil Perviousness

1. **Rapidly pervious** - the capacity to transmit water vertically is so great that the soil will remain wet for no more than a few hours after thorough wetting. The horizons and soils have large and continuous connecting pores and cracks that do not close with wetting.

2. **Moderately pervious** - the capacity to transmitt water vertically is great enough that the soil will remain saturated for no more than a few days after thorough wetting. Most moderately pervious soils hold relatively large amounts of water against the force of gravity, and are considered good, physically, for rooting and supplying water to plants.

3. **Slowly pervious** - the potential to transmit water vertically is so slow that the horizons or the soil will remain saturated for periods of a week or more after thorough wetting.

Appendix IV
Ecological Moisture Classes

MOISTURE REGIME	DEFINING CHARACTERISTICS		FIELD RECOGNITION CHARACTERISTICS						SLOPE GRADIENT
				SOIL PROPERTIES					
	DESCRIPTION	PRIMARY WATER SOURCE	SLOPE POSITION	TEXTURE	DRAINAGE	DEPTH TO IMPERMEABLE LAYER	SURFACE HUMUS DEPTH	AVAILABLE WATER STOR. CAP	
VERY XERIC a	Water removed extremely rapidly in relation to supply, soil is moist for a negligible time after ppt	precipitation	ridge crests shedding	very coarse (gravelly-s) abundant coarse fragments	very rapid	very shallow (<0.5m)	very shallow	extremely low	very steep (especially on south aspects)
XERIC b	Water removed very rapidly in relation to supply; soil is moist for brief periods following ppt	precipitation			rapid				
SUBXERIC c	Water removed rapidly in relation to supply; soil is moist for short periods following ppt	precipitation	upper slopes shedding	coarse to mod. coarse (LS-SL) mod. coarse fragments	rapid to well	shallow (<1m)	shallow	very low	steep
SUBMESIC d	Water removed readily in relation to supply; water available for moderately short periods following ppt	precipitation						low	moderate
MESIC e	Water removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short period of the year. Available soil moisture reflect climatic inputs.	precipitation in moderately to fine-textured soils & limited seepage in coarse textured soils	mid-slope-normal rolling to flat	moderate to fine (L-SiL) few coarse fragments	well to moderately well	moderately deep (1-2 m)	moderately deep	moderate	
SUBHYGRIC f	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possibly mottling below 20 cm	precipitation and seepage			moderately well to imperfect	deep (>2 m)	deep	high	slight
HYGRIC g	Water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possibly weak gleying	seepage	lower slopes receiving	variable depending on seepage	imperfect to poor	variable depending on seepage		variable depending on seepage	
SUBHYDRIC h	Water removed slowly enough to keep the water table at or near the surface for most of the year; gleyed mineral or organic soils; permanent seepage less than 30 cm below the surface	seepage or permanent water table			poor to very poor		very deep		
HYDRIC i	Water removed so slowly that the water table is at or above the soil surface all year; gleyed mineral or organic soils	permanent water table	depressions receiving	Variable depending on seepage	very poor	variable depending on seepage		variable depending on seepage	flat

Appendix V. Species Occurring within the Macmillan Pass/Sheldon Lake Study Area

Vascular plant nomenclature follows Hulten (1968) ; lichens follow Hale (1969).

1. The number in the columns indicates the percent of the sites in which the species was recorded.
2. + - indicates that the species was recorded in less than 10% of the stands in trace amounts, and was deleted from the data analysis.
3. * - indicates that the species was present in trace amounts and was used in the data analysis.
4. ++ - indicates that the species occurred in the study area but was grouped with other species for data analysis.

Note: some species are listed under more than one growth-form (e.g., *Betula occidentalis*) .

Willows, grasses and sedges were identified by W. Cody, National Herbarium, Ottawa; lichens by P.Y. Wong and bryophytes by R.R. Ireland, Museum of Natural Sciences, Ottawa.

TREES

Pinaceae	Alpine	Treed	Below
Pinus contorta Dougl. ex Loud. var. *latifolia*		*	
Picea glauca (Moench) Voss	21	31	+
Picea mariana (Mill.) Britt.,Sterns & Pogg.	12	49	2
Abies lasiocarpa (Hook.) Nutt.	10	55	17
Salicaceae			
Populus balsamifera L.ssp.*balsamifera*	1	2	
Populus tremuloides Michx.	1	3	
Betulaceae			
Betula occidentalis Hook.			
ERECT SHRUBS			
Salicaceae			
Salix alaxensis (Anderss.) Cov.	++		++
Salix bebbiana Sarg.		++	++
Salix glauca L.	++	++	++
Salix lanata L.ssp.*Richardsonii* (Hook.) A.Skvortro		++	++
Salix longistylis Rydb.		++	
Salix myrtillifolia Anders.	++	++	++
Salix planifolia Pursh.	++	++	++
Salix pulchra Cham.	++	++	++
Salix Scouleriana Barratt	++	++	
Salix spp.	52	64	42
Betulaceae			
Betula glandulosa Michx.	72	73	30
Betula occidentalis Hook.	1		
Alnus crispa (Ait.) Pursh		4	
Alnus tenuifolia Nutt.		1	
Saxifragaceae			
Ribes hudsonianum Richards.		*	
Ribes triste Pall.	3	11	
Ribes sp.		2	0
Rosaceae			
Spirea Beauverdiana Schneid.	1	15	18
Rubus idaeus L.	1		
Rubus sp.	1	*	
Potentilla fruticosa L.	4	3	3
Rosa acicularis Lindl.	3	17	3
Elaeagnaceae			

Shepherdia canadenis (L.) Nutt.		3	
Ericaceae			
Ledum palustre L.ssp.*decumbens* (Ait.) Hult.	++	++	4
Ledum palustre L.spp.*groenlandicum* (Oeder) Hult.	35	71	9
Kalmia polifolia Wang.	4	1	+
Andromeda polifolia L.	2	+	
Chamaedaphne calyculata (L.) Moench	3		
Vaccinium uliginosum L.	38	76	42
Caprifoliaceae			
Viburnum edule (Michx.) Raf.		1	1
PROSTRATE SHRUBS			
Cupressaceae			
Juniperus communis L.		3	6
Juniperus horizontalis Moench		1	
Salicaceae			
Salix arctica Pall.	2	1	7
Salix reticulata L.	5	3	11
Rosaceae			
Dryas integrifolia M.Vahl			7
Dryas octopetala L.			+
Empetraceae			
Empetrum nigrum L. spp. *hermaphroditum* (Lange) Bocher	25	76	49
Ericaceae			
Phyllodoce empetriformis (Sm.) D.Don		1	9
Cassiope tetragona (L.) D.Don		13	51
Arctostaphylos uva-ursi (L.) Spreng.	1	2	
Arctostaphylos alpina (L.) Spreng.			2
Arctostaphylos rubra (Rehd. & Wilson) Fern.	7	10	13
Vaccinium vitis-idaea L. spp. *minus* (Lodd.) Hult.	52	85	64
Oxycoccus microcarpus Turcz.	9	22	+
Caprifoliaceae			
Linnaea borealis L. ssp.*americana* (Forbes) Hult.	1	11	3
FORBS			
Liliaceae			
Tofieldia spp.	2		
Zygadenus elegans Pursh		+	2
Veratrum viride Ait.spp. *Eschscholtzii* (Gray) Love & Love	1	1	9
Streptopus amplexifolius (L.) DC.		+	
Orchidaceae			
Spiranthes Romanzoffiana Cham.	1	+	

Santalaceae			
Geocaulon lividum (Richards.) Fern.	1	5	
Polygonaceae			
Rumex arcticus Trautv.	14	2	7
Oxyria digyna (L.) Hill			2
Polygonum viviparum L.	3	+	2
Polygonum bistorta L.			2
Polygonum alaskanum (Small) Wight	2	1	7
Portulacaceae			
Claytonia tuberosa Pall.			+
Caryophyllaceae			
Stellaria longipes Goldie	1		+
Cerastium Beeringianum Cham. & Schlecht.			+
Arenaria capillaris Poir.			+
Moehringia lateriflora (L.) Fenzl			+
Wilhelmsia physodes (Fisch.) McNeill		*	
Silene acaulis L.			2
Ranunculaceae			
Delphinium glaucum S.Wats.	1		2
Aconitum delphinifolium DC. ssp. *delphinifolium*	17	4	9
Anemone Richardsonii Hook.		+	+
Anemone parviflora Michx.	1	+	8
Anemone narcissiflora L. spp. *interior* Hult.	1	2	14
Anemone multifida Poir.	1	2	21
Anemone spp.			5
Thalictrum sparsiflorum Turcz.	4	+	+
Ranunculus Eschscholtzii Schlecht.		+	+
Ranunculus spp.		3	
Cruciferae			
Draba nivalis Liljebl.			+1
Draba aurea Vahl			+1
Parrya nudicaulis (L.) Regel		+	2
Crassulaceae			
Sedum rosea (L.) Scop.	2	+	8
Saxifragaceae			
Saxifraga oppositifolia L.			
Saxifraga flagellaris Willd.			1
Saxifraga tricuspidata Rottb.			
Saxifraga exilis Steph.			
Saxifraga nivalis L.			+
Saxifraga punctata L. ssp. *Porsildiana* Calder & Savile			+
Chrysosplenium tetrandrum (Lund) T. Fries	1		
Parnassia fimbriata Konig	3		1
Parnassia palustris L.	5	*	+
Parnassia montanensis Fern + Rydb.			

Rosaceae			
Rubus chamaemorus L.	8	39	4
Rubus arcticus L. ssp. *acaulis* (Michx.) Focke	23	11	12
Potentilla palustris (L.) Scop.	17	*	+
Potentilla uniflora Ledeb.			4
Potentilla hyparctica Malte			7
Potentilla gracilis Dougl.			+
Sibbaldia procumbens L.			1
Geum macrophyllum Willd. ssp. *perincisum* (Rydb.) Hult.	2		
Geum aleppicum Jacq. ssp. *strictum* (Ait.) Claosen	1		
Leguminosae			
Lupinus arcticus S. Wats.	5	12	5
Astragalus eucosmus Robins. ssp. *eucosmus*		1	
Astragalus alpinus L. ssp. alpinus		+	
Oxytropis nigrescens (Pall.) Fisch.		+	2
Oxytropis Maydelliana Trautv.			2
Hedysarum alpinum L. ssp. *americanum* (Michx.) Fedtsch.		2	
Violaceae			
Viola epipsila Ledeb. ssp. *repens* (Turcz.) Becker	4	+	+
Onagraceae			
Epilobium angustifolium L.	21	17	20
Epilobium latifolium L.	1		5
Epilobium leptophyllum Raf.	1		
Umbelliferae			
Heracleum lanatum Michx.			5
Cornaceae			
Cornus canadensis L.	10	30	5
Cornus canadensis L. x *suecica* L.		*	
Pyrolaceae			
Pyrola asarifolia Michx.	1	4	6
Pyrola minor L.		1	
Pyrola secunda L.	3	6	+
Moneses uniflora (L.) Gray	1	2	
Primulaceae			
Dodecatheon frigidum Cham.&Schlecht.	2	1	2
Gentianaceae			
Gentiana glauca Pall.	1	+	47
Gentiana propinqua Richards.	1	1	+
Menyanthes trifoliata L.	1		
Polemoniaceae			
Polemonium acutiflorum Willd.	28	6	16

Boraginaceae			
Myosotis alpestris F.W. Schmidt			7
Mertensia paniculata (Ait.) G.Don	13	15	16
			F
Scrophulariaceae			
Linaria vulgaris Mill.		1	
Veronica Wormskjoldii Roem. & Schult.	2		+
Lagotis glauca Gaertn. ssp. *minor* (Willd.) Hult.			1
Pedicularis verticillata L.	1	+	
Pedicularis labradorica Wirsing	8	9	16
Pedicularis Langsdorffii Fisch.		1	6
Pedicularis sudetica Willd.	1	+	
Pedicularis capitata Adams		+	
Pedicularis Kanei Durand	2	+	
Orobanchaceae			
Boschniakia rossica (Cham. & Schlecht.) Fedtsch.		+	
Lentibulariaceae			
Pinguicula villosa L.		2	
Rubiaceae			
Galium boreale L.		+	
Valerianaceae			
Valeriana capitata Pall.	1	+	2
Valeriana sitchensis Bong.	1	*	3
Campanulaceae			
Campanula lasiocarpa Cham.			+
Compositae			
Solidago multiradiata Ait.	3	1	2
Aster sibiricus L.	1	+	
Antennaria monocephala DC.			4
Achillea borealis Bong.	7	+	
Artemisia Tilesii Ledeb.	1		
Artemisia arctica Less.	7	6	54
Petasites frigidus (L.) Franch.	9	20	9
Arnica latifolia Bong. f			1
Senecio yukonensis Pors.			+
Senecio atropurpureus (Ledeb.) Fedtsch.	4	2	10
Senecio cymbalarioides Nutt.			+
Senecio triangularis Hook.	12	+	11
Senecio sheldonensis Pors.			1
Sencio lugens Richards.	5	4	8
Saussurea angustifolia (Willd.) DC.			+
Taraxacum hyparcticum			1
Hieracium gracile Hook.		+	2
Hieracium triste Willd.			1

GRAMINOIDS

Gramineae

Hierochloe alpina (Sw.) Roem. & Schult.	2	2	38
Hierochloe odorata (L.) Wahlenb.		+	
Phleum commutatum Gandoger var. *americanum* (Fourn.) Hult.	2		2
Alopecurus aequalis Sobol.	1		
Arctagrostis latifolia (R.Br.) Griseb.	6	6	2
Calamagrostis canadensis (Michx.) Beauv.	6	7	15
Calamagrostis neglecta (Ehrh.) Gaertn.,Mey. & Schreb.			2
Calamagrostis purpurascens R.Br.		+	1
Calamagrostis spp.	10	9	6
Deschampsia brevifolia R.Br.			2
Trisetum spicatum (L.) Richter		*	2
Poa alpina L.		*	2
Poa lanata Scribn. & Merr.	1	*	5
Festuca altaica Trin.	43	21	62
Festuca brachyphylla Schult.			1
Festuca rubra L.coll.	1	+	
Festuca saximontana Rydb.		+	
Festuca sp.		2	

Cyperaceae

Eriophorum angustifolium Honck.	1	+	+
Eriophorum spp.	1	*	
Scirpus spp.	0	*	0
Carex leptalea Wahlenb.	0	+	0
Carex praticola Rydb.	1	0	0
Carex canescens L.	1	0	0
Carex brunnescens (Pers.) Poir.	0	0	+
Carex Bigelowii Torr.	1	0	4
Carex aquatilis Wahlenb.	29	2	5
Carex podocarpa C.B.Clarke	1	+	40
Carex microchaeta Holm	0	0	5
Carex concinna R.Br.	0	+	0
Carex vaginata Tausch	0	+	0
Carex rostrata Stokes	5	+	0
Carex membranacea Hook.	0	0	1
Carex rufina Drez.	0	*	0
Carex spp.	2	*	0

Juncaceae

Luzula parviflora (Ehrh.) Desv.	4	2	37
Luzula arcuata (Wahlenb.) Sw.	0	0	+
Luzula confusa Lindeb.	0	0	5
Luzula spp.	1	0	2

PTERIDOPHYTES

Lycopodiaceae

Lycopodium selago L.	1	3	15
Lycopodium annotinum L.	0	7	+
Lycopodium clavatum L.	0	2	+
Lycopodium alpinum L.	1	6	23
Lycopodium complanatum L.	0	2	0
Lycopodium spp.	0	1	0

Equisetaceae			
Equisetum scirpoides Michx.	1	7	+
Equisetum palustre L.	1	1	0
Equisetum silvaticum L.	3	33	+
Equisetum pratense L.	2	2	0
Equisetum arvense L.	4	6	+
Equisetum spp.	1	1	0
Athyriaceae			
Cystopteris fragilis (L.) Bernh.	0	0	+
BRYOPHYTES			
Sphagnaceae			
Sphagnum spp.	32	45	7
Ditrichaceae			
Ditrichum flexicaule (Schwaegr.) Hampe.	0	*	0
Dicranaceae			
Dicranum acutifolium (Lindb. and Arnell) C.Jens. ex Weim	0	1	+
Dicranum elongatum Schleich. ex Schwaegr.	0	0	+
Dicranum spadiceum Zett	0	+	0
Dicranum spp.	31	57	60
Pottiaceae			
Tortula ruralis (Hedw.) Gaertn., Meyer and Scherb.	1	0	+
Grimmiaceae			
Rhacomitrium canescens var. *ericoides* (Brid.) Hampe	0	+	+
Rhacomtrium lanuginosum (Hedw.) Brid.	0	*	4
Miniaceae			
Rhizomnium spp.	0	0	+
Bryaceae			
Pohlia nutans (Hedw.) Lindb.	0	0	+
Aulacomniaceae			
Aulacomnium palustre (Hedw.) Schwaegr.	++	++	++
Aulacomnium turgidum (Wahlenb.) Schwaegr.	0	0	+
Aulacomnium spp.	44	38	39
Meesiaceae			
Paludella squarossa (Hedw.) Brid.	+	+	+
Bartramiaceae			
Philonotis fontana (Hedw.) Brid.	1	0	+

Philonotis fontana var. *pumila* (Turn.) Brid.	0	0	+
Philonotis spp.	0	+	0
Thuidiaceae			
Thuidium abietinum (Hedw.) Kind	0	*	0
Helodium Blandowii (Web. and Mohr) Warnst	1	0	0
Amblystegiaceae			
Drepanocladus uncinatus (Hedw.) Warnst.	+	*	0
Drepanocladus exannulatus (B.S.G.) Warnst.	+	0	0
*Drepanocladus*spp. (Hedw.) C.Jens	6	5	5
Campylium stellatum (Hedw.) C.Jens	10	+	0
Scorpidium scorpioides (Hedw.) Schaegr.	1	0	0
Calliergon stramineum (Brid.) Kindb.	+	0	+
Calliergon sarmintosum(Wahlenb.) Kindb.	0	*	0
Calliergon gigantium (Schimp.) Kindb.	2	0	0
Brachytheciaceae			
Tomenthypnum nitens (Hedw.) Loeske	13	4	15
Brachythecium spp.	0	1	+
Entodontaceae			
Pleurozium schreberi	50	71	42
Hypnaceae			
Hypnum lindbergii Mitt.	0	0	+
Hypnum plicatulum (Lindb.) Jaeg. and Saverb.	0	*	0
Hypnum spp.	1	1	4
Ptilium crista-castrensis (Hedw.) DeNot.	0	6	1
Rhytidiaceae			
Rhytidium rugosum (Hedw.) Kindb.	0	*	+
Rhytidiadelphus subpinnatus (Lindb.) Kop.	0	0	+
Hylocomiaceae			
Hylocomium pyrenaicum (Spruce) Lindb.	+	0	0
Hylocomium splendens (Hedw.) B.S.G.	31	59	36
Climaceaceae			
Climacium dendroides (Hedw.) Web and Mohr.	2	0	0
Polytrichaceae			
Polytrichum juniperinum Hedw.	70	68	70
Polytrichum commune Hedw.	3	6	11
Polytrichum commune var. *nigriscens* Warnst.	0	0	+
Polytrichum strictum Brid.	+	0	0
Polytrichum spp.			
Unknown bryophytes	0	1	0
LIVERWORTS			
Tritomaria guinguedentata (Huds.) Buch	0	+	0

Barbilophozia kunzeana (Hub.) Gams	1	+	0
Ptilidium pulcherremum (Web.) Hampe	0	0	+
Ptilidium ciliare (L.) Hampe	0	1	0
Leafy liverworts	45	41	20
LICHENS			
Parmeliaceae			
Cetraria cucullata (Bell.) Ach.	30	13	45
Cetraria nivalis (L.) Ach.	29	22	45
Cetraria islandica (L.) Ach.	7	11	40
Cetraria richardsonii (L.) Ach.	4	6	46
Cetraria spp.	1		
Dactylina arctica (Hook.) Nyl.	4	19	57
Cladoniaceae			
Cladina rangiferina (L.) Harm	45	55	29
Cladina mitis (L.) (Sandst.) Hale and Culb.	34	56	39
Cladina stellaris (Opiz) Brodo	54	74	58
Cladonia spp.	51	80	55
Cladonia coccifera	2	28	3
Cladonia uncialis (L.) Wigg.	2	28	3
Cladonia amaurocraea (Florke) Schaer.			
Cladonia bellidiflora (Ach.) Schaer.			
Cladonia cenotea (Ach.) Schaer.			
Cladonia crispata (Ach.) Flot.			
Cladonia deformis (L.) Hoffm.			
Cladonia ecmocyna (S.Gray) Leight.			
Cladonia ecmocyna (S.Gray) Leight. var. intermedia (Robb.) Evans			
Cladonia gracilis (L.) Willd. ssp. *gracilis*			
Cladonia gracilis (L.) Willd. ssp. *nigripes* (Nyl.) Ahti			
Cladonia gracilis (L.) Willd. ssp. *turbinata* (Ach.) Ahti			
Cladonia phyllophora Hoffm.			
Cladonia pleurota (Florke) Schaer.			
Cladonia stricta (Nyl.) Nyl.			
Cladonia sulphurina (Michx.) Fries			
Peltigeraceae			
Peltigera aphthosa (L.) Willd.	28	52	18
Peltigera canina (L.) Willd.	13	24	0
Peltigera scabrosa Th. Fr.			0
Nephroma arcticum (L.) Torss.	27	67	38
Nephroma expallidum (Nyl.) Nyl.	0	*	0
Stereocaulaceae			
Stereocaulon tomentosum Fr.	++	++	++
Stereocaulon paschale(L.) Hoffm.	++	++	++
Stereocaulon spp.	38	20	63
Usneaceae			
Alectoria ochroleuca (Hoffm.) Mass.	2	0	27
Alectoria nigricans (Ach.) Nyl.	1	+	2
Alectoria spp.	0	0	13
Lobaria linita (Ach.) Rabenh.			
Ichmadophila erictoreum (L.)Zahlbr.	0	10	12

Appendix VI. DECORANA Ordination Site Coordinates

Appendix VI

Above Treeline Non-treed Subalpine and Alpine Sites

DECORANA Ordination - Site Coordinates

	Site	AX1	AX2	AX3	AX4
1	003	294	150	0	88
2	004	599	137	138	95
3	012	407	104	230	198
4	013	166	129	146	63
6	017	316	112	296	289
7	018	172	7	231	48
8	020	601	162	163	30
9	026	121	235	194	146
10	029	82	255	110	218
11	031	336	126	129	154
12	032	199	386	199	188
13	036	103	226	197	125
14	043	186	280	258	92
16	046	24	119	165	196
17	049	95	239	164	137
18	050	113	221	182	134
19	060	74	87	169	99
20	061	231	37	297	374
21	062	286	83	224	329
22	063	264	100	167	100
23	064	267	81	115	87
24	065	169	90	166	56
26	069	133	340	131	186
27	070	91	212	85	126
28	071	216	187	372	72
29	072	294	108	276	0
30	077	67	64	196	111
31	078	48	101	177	155
32	081	262	116	132	129
33	088	170	175	201	132
34	089	54	0	139	192
35	090	58	37	164	196
36	095	11	123	164	157
37	096	87	114	172	122
38	109	76	30	165	149
39	111	325	198	276	72
40	126	174	164	246	132
41	127	48	105	174	166
42	135	77	262	108	158
43	147	51	109	156	106
44	150	0	75	185	244
45	151	51	154	145	145
46	158	244	169	327	121
47	164	121	219	130	198

48	168	128	113	263	137
49	177	51	229	148	127
50	178	93	229	115	211
51	179	269	471	190	145
52	190	199	147	49	150
53	196	70	107	177	171
54	197	179	166	333	70
55	215	101	130	200	98
56	220	118	252	178	175
57	221	127	260	222	143
58	222	213	104	312	22
59	230	248	110	262	138
60	240	22	108	139	198
61	241	61	227	155	134
62	254	7	75	177	208
63	256	127	168	231	117
64	257	78	257	101	209
65	262	92	93	151	192
66	275	275	290	112	111
67	279	54	207	220	160
68	293	133	12	172	100
69	295	38	190	128	135
70	298	161	170	223	113
71	303	73	212	165	199
72	304	92	180	165	153
73	312	121	172	242	108
74	317	139	191	236	140
75	318	87	284	193	170
76	319	122	236	254	157
77	323	101	220	165	187
78	326	18	178	130	172
79	332	54	219	153	137
80	335	30	102	182	211
81	336	210	224	138	134
82	340	111	83	181	151
83	341	224	169	261	184
84	354	46	85	179	164
85	355	178	139	178	108
86	372	163	184	169	117
87	374	127	188	220	145
88	375	83	206	199	151
89	376	182	213	301	107
90	382	60	224	160	142
91	397	81	31	196	96
92	398	132	89	182	72
93	407	83	154	173	121
94	421	154	107	173	277
95	422	242	194	153	243
96	425	47	125	170	149
97	426	212	155	96	167
98	429	25	196	129	134
99	430	218	252	202	111
100	439	54	249	131	201
101	440	92	216	183	181

102	444	232	101	110	125
103	445	110	85	163	116
104	446	36	165	145	137
105	448	71	236	177	218
106	449	50	176	130	120
107	451	74	257	153	198
108	452	92	260	157	172
109	477	100	64	160	185

Appendix VI cont.

Forested Sites - DECORANA Ordination Coordinates

	Site	AX1	AX2	AX3	AX4
1	1	185	132	34	64
2	9	266	118	63	89
3	11	138	155	80	69
4	15	223	178	48	105
5	19	158	199	49	76
6	21	37	175	146	60
7	22	46	58	109	84
8	27	89	218	124	76
9	28	223	133	43	65
10	30	202	199	15	79
11	33	198	69	103	59
12	35	122	65	144	54
13	37	79	235	161	59
14	39	165	50	137	83
15	44	180	225	43	114
16	47	287	50	239	212
17	48	257	95	63	64
18	51	102	209	101	112
19	52	116	209	140	86
20	53	183	94	132	65
21	55	195	158	62	87
22	57	176	69	104	76
23	58	225	128	68	83
24	66	207	74	111	56
25	67	87	53	120	88
26	73	221	160	42	80
27	75	225	106	64	52
28	76	111	201	265	41
29	79	95	105	235	24
30	80	329	91	237	160
31	82	175	190	62	75
32	83	209	102	225	134
33	84	46	94	159	60
34	85	240	83	83	81
35	87	176	251	4	92
36	91	126	187	59	137
37	92	140	138	98	131
38	93	82	177	141	102
39	94	258	103	68	72
40	97	147	84	72	84
41	98	188	55	117	68
42	99	0	126	136	81
43	101	59	28	81	123
44	102	85	110	122	110
45	103	51	39	83	142
46	104	55	123	97	135
47	105	63	29	88	151

48	106	300	95	103	149
49	107	119	263	224	154
50	108	141	43	92	49
51	112	92	73	106	170
52	113	86	177	44	199
53	114	46	164	146	95
54	116	33	216	97	78
55	118	91	165	272	11
56	119	247	62	204	151
57	120	196	83	95	79
58	121	43	158	122	96
59	122	88	150	54	124
60	123	34	172	109	103
61	125	108	73	104	114
62	129	46	47	127	88
63	131	122	31	110	51
64	132	170	45	84	53
65	133	296	106	41	58
66	134	49	159	109	71
67	136	152	155	43	115
68	138	252	132	310	233
69	139	55	44	99	109
70	142	183	145	64	118
71	143	56	89	122	101
72	144	102	25	125	97
73	148	173	167	42	115
74	153	67	228	108	125
75	157	98	203	62	160
76	160	81	41	100	138
77	161	102	133	210	61
78	162	172	26	130	84
79	163	117	245	136	53
80	167	33	121	99	140
81	169	75	90	104	145
82	170	307	78	145	197
83	171	41	80	84	181
84	174	36	9	102	81
85	175	104	124	216	59
86	176	71	66	111	121
87	180	19	168	141	84
88	181	105	59	63	100
89	184	37	88	87	149
90	185	249	95	98	71
91	186	55	50	97	111
92	187	105	58	183	54
93	188	123	27	90	52
94	189	65	26	89	130
95	191	108	155	53	105
96	192	84	129	68	123
97	193	41	171	98	131
98	198	212	170	40	89
99	200	248	86	70	82
100	202	94	255	162	111
101	205	74	25	161	46

102	206	29	75	113	96
103	207	116	43	83	70
104	209	50	65	99	130
105	210	67	22	122	68
106	211	31	173	133	88
107	212	88	140	196	83
108	213	184	94	68	90
109	219	272	82	89	108
110	223	63	57	73	154
111	227	51	81	85	125
112	228	245	117	88	78
113	229	160	112	63	138
114	231	90	276	80	101
115	232	124	207	149	137
116	233	185	112	79	156
117	237	64	128	138	103
118	239	113	15	134	92
119	242	137	155	118	224
120	243	252	125	70	107
121	246	197	78	102	186
122	247	293	94	50	75
123	248	238	92	220	200
124	255	188	89	71	71
125	258	161	229	50	75
126	259	135	193	77	64
127	261	59	247	144	61
128	263	102	232	55	141
129	264	69	43	92	115
130	265	104	135	190	95
131	268	147	86	70	196
132	272	140	81	94	117
133	274	228	181	10	77
134	276	56	171	66	139
135	277	64	95	80	132
136	278	76	193	297	0
137	280	193	220	0	78
138	281	212	93	99	75
139	282	234	172	20	72
140	283	243	51	206	199
141	285	126	170	88	164
142	286	263	113	277	238
143	287	149	112	162	99
144	288	181	79	88	96
145	291	118	143	193	81
146	292	57	24	105	110
147	294	174	7	131	202
148	296	63	30	91	122
149	297	116	74	103	166
150	299	53	136	79	151
151	300	126	44	83	102
152	305	77	15	97	111
153	306	231	70	117	93
154	308	79	37	110	128
155	309	40	84	112	105

156	310	158	61	110	57
157	313	188	128	180	154
158	314	188	114	189	161
159	315	82	126	171	64
160	320	85	200	77	136
161	321	36	216	125	96
162	322	86	256	87	139
163	324	225	71	88	111
164	325	68	129	166	95
165	327	85	215	52	170
166	328	62	106	93	122
167	330	256	80	86	119
168	333	29	54	122	87
169	334	53	91	111	130
170	337	98	233	65	160
171	343	140	120	62	83
172	345	39	206	128	101
173	346	68	85	72	152
174	350	51	109	126	91
175	352	52	173	126	102
176	356	176	188	47	94
177	357	126	220	53	124
178	359	59	100	114	124
179	361	93	89	99	146
180	364	140	103	75	74
181	366	171	108	110	92
182	367	63	37	105	99
183	368	171	80	103	194
184	369	50	119	110	127
185	370	221	165	9	68
186	371	87	79	69	180
187	373	33	212	143	89
188	377	54	115	193	26
189	378	85	132	186	54
190	379	99	167	276	19
191	381	83	236	136	113
192	384	106	276	99	139
193	385	135	29	101	63
194	387	31	65	101	115
195	388	91	85	124	128
196	390	239	81	91	79
197	392	29	47	89	125
198	393	20	26	96	96
199	394	27	5	111	58
200	395	6	116	117	103
201	396	28	34	100	99
202	399	36	233	194	47
203	400	77	163	65	175
204	402	160	170	327	72
205	403	81	97	147	102
206	404	161	162	65	98
207	405	26	156	108	128
208	406	120	82	113	63
209	408	108	132	144	76

210	409	81	156	50	199
211	411	31	41	120	82
212	413	92	42	101	96
213	414	88	72	94	177
214	416	155	71	176	119
215	417	46	103	157	73
216	428	220	45	78	89
217	434	43	0	107	74
218	435	128	96	87	201
219	436	33	57	115	98
220	441	91	200	91	155
221	442	230	122	52	74
222	443	94	158	60	148
223	453	117	250	23	169
224	454	86	175	36	208
225	456	123	54	86	107
226	457	264	134	51	94
227	458	75	69	85	168
228	459	277	97	102	98
229	460	65	72	90	164
230	463	56	58	84	106
231	464	62	8	115	83
232	466	233	111	257	242
233	470	192	59	217	115
234	471	269	70	151	149
235	472	145	50	105	58
236	473	10	99	108	116
237	474	60	41	97	142
238	475	93	71	96	117
239	476	45	131	79	139
240	482	175	61	96	60
241	483	54	50	101	139
242	484	250	125	103	109
243	485	224	77	67	66
244	488	70	166	72	175
245	489	49	109	73	171
246	491	283	93	68	63

Appendix VI cont.

Non-treed Below Treeline Sites

DECORANA Ordination - Site Coordinates

	Site	AX1	AX2	AX3	AX4
1	2	104	143	113	349
2	5	97	132	105	352
3	7	62	152	109	330
4	8	331	203	148	239
5	10	72	170	101	303
6	16	181	235	163	389
7	23	23	166	118	336
8	24	17	169	123	338
9	25	0	154	148	343
10	34	99	205	122	266
11	38	405	125	65	386
12	40	95	137	99	340
13	54	108	233	146	321
14	56	26	169	124	328
15	59	396	190	119	291
16	74	356	28	197	210
17	110	34	174	132	329
18	117	353	100	87	374
19	124	443	198	121	495
20	128	44	184	147	344
21	130	142	274	84	230
23	140	85	229	88	245
24	141	427	207	99	455
25	155	132	218	179	346
26	165	386	159	89	412
27	166	62	174	171	349
28	173	46	178	139	333
30	183	361	360	110	265
31	194	59	197	156	352
32	199	342	29	173	245
33	201	58	202	140	321
34	203	139	228	205	383
35	204	100	234	167	343
36	208	301	13	62	314
37	214	355	241	119	320
38	216	32	171	152	345
39	217	271	204	181	294
40	218	329	0	292	219
41	224	125	110	88	354
42	225	354	239	159	266
43	226	243	199	217	432
44	234	415	163	68	418
45	235	91	222	178	373
46	236	57	199	144	338
47	238	110	211	191	367

48	244	336	218	145	346
49	245	141	113	109	354
50	249	67	189	154	352
51	250	68	171	88	300
52	260	332	193	83	414
53	266	67	198	154	346
54	267	339	250	127	289
55	269	62	198	155	354
56	270	68	170	185	370
57	271	72	201	180	363
58	284	362	120	155	344
59	289	57	174	134	334
60	290	262	77	111	384
61	301	209	229	196	401
62	302	180	147	186	331
63	307	499	208	68	0
64	311	388	205	141	314
65	316	412	240	150	409
66	329	365	317	103	320
67	331	35	177	141	311
68	338	221	226	122	297
69	339	94	217	170	361
70	342	81	190	175	356
71	344	334	88	116	292
72	347	124	223	198	374
73	348	14	170	130	334
74	349	110	215	147	335
75	351	373	103	314	446
76	353	397	212	164	202
77	358	429	136	136	354
78	362	123	218	174	325
79	363	259	96	249	423
80	365	375	161	156	329
81	380	279	258	130	374
82	383	344	63	52	375
83	386	74	180	147	348
84	389	74	202	111	285
85	391	373	67	230	239
86	401	422	174	0	458
87	410	382	240	138	399
88	412	463	208	128	125
89	418	216	131	240	408
90	427	61	202	135	315
91	431	413	253	131	303
92	432	16	177	126	316
93	433	35	171	154	343
94	437	297	295	124	343
95	438	405	174	143	385
96	447	108	217	179	358
97	461	397	147	159	167
98	462	107	230	182	362
99	465	75	202	169	359
100	467	269	26	56	320
101	468	178	156	98	332

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102   469            152   174   122   322
103   479            396   161   156   357
104   486            164   155   187   282
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Appendix VI cont.

Non-treed Below Treeline Submesic Sites

DECORANA Ordination - Site Coordinates

	Site	AX1	AX2	AX3	AX4
1	2	39	102	29	33
2	5	18	90	21	23
3	7	22	57	56	44
5	10	37	70	87	4
6	16	173	76	75	25
7	23	31	11	72	61
8	24	36	6	67	57
9	25	36	3	42	72
10	34	101	124	158	64
12	40	16	83	36	15
13	54	148	78	120	0
14	56	38	23	80	76
17	110	48	28	78	75
20	128	76	23	66	56
23	140	75	91	186	15
25	155	155	102	73	67
27	166	94	60	49	84
28	173	63	41	71	64
31	194	99	26	68	51
33	201	91	44	95	30
34	203	202	61	66	33
35	204	150	48	99	27
38	216	64	22	56	71
41	224	0	126	3	14
45	235	150	30	64	35
46	236	92	31	77	31
47	238	159	74	58	60
49	245	25	149	0	31
50	249	96	48	59	54
51	250	16	45	123	91
53	266	102	44	71	53
55	269	99	18	70	30
56	270	95	66	0	95
57	271	127	34	60	55
59	289	63	43	67	48
62	302	118	146	39	108
67	331	49	38	95	109
69	339	140	46	72	48
70	342	116	49	58	58
72	347	179	85	50	59
73	348	33	0	84	103
74	349	124	89	85	45
78	362	136	94	88	80
83	386	83	57	54	54
84	389	50	57	148	33

90	427	79	36	106	46
92	432	39	12	85	46
93	433	63	25	65	92
96	447	156	67	74	49
98	462	171	65	79	41
99	465	122	37	59	37
101	468	76	225	22	61
102	469	91	192	45	71
104	486	121	153	111	146

Appendix VI cont.

Non-treed Below Treeline - Subhygric Sites

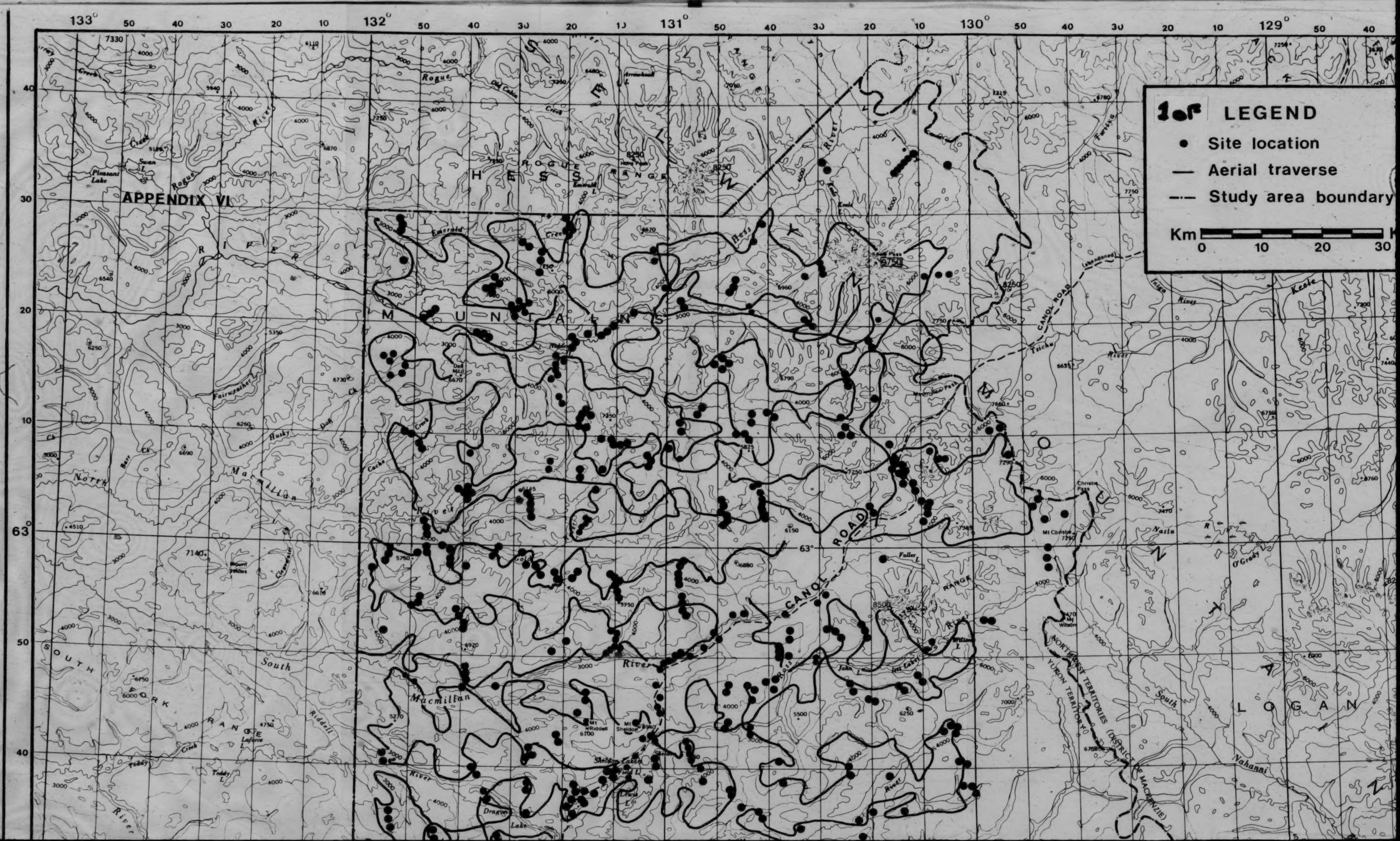
DECORANA Ordination - Site Coordinates

	Site	AX1	AX2	AX3	AX4
4	8	167	214	22	106
11	38	97	123	112	59
15	59	177	183	98	76
16	74	131	362	76	57
18	117	75	196	90	99
19	124	113	88	240	58
24	141	118	109	203	23
26	165	85	130	96	73
30	183	207	96	0	157
32	199	124	344	84	72
36	208	48	287	72	98
37	214	156	144	60	66
39	217	147	207	6	0
42	225	167	181	28	124
44	234	102	152	160	51
48	244	145	160	68	26
52	260	99	63	65	24
54	267	181	127	47	87
58	284	111	228	137	27
60	290	0	268	102	78
63	307	453	198	82	101
64	311	156	176	85	102
65	316	133	118	136	118
66	329	163	99	37	114
71	344	108	244	61	104
76	353	226	215	87	87
77	358	169	176	206	113
80	365	135	201	76	120
82	383	55	229	123	128
85	391	162	294	166	43
86	401	60	0	97	3
87	410	111	132	75	204
88	412	383	195	159	107
91	431	178	149	102	86
94	437	150	89	22	57
95	438	135	163	138	94
97	461	255	240	79	77
100	467	33	280	56	90
103	479	146	178	145	79

Appendix VII. Site Locations and Flight Traverse Lines

See map pocket on back cover.

APPENDIX VI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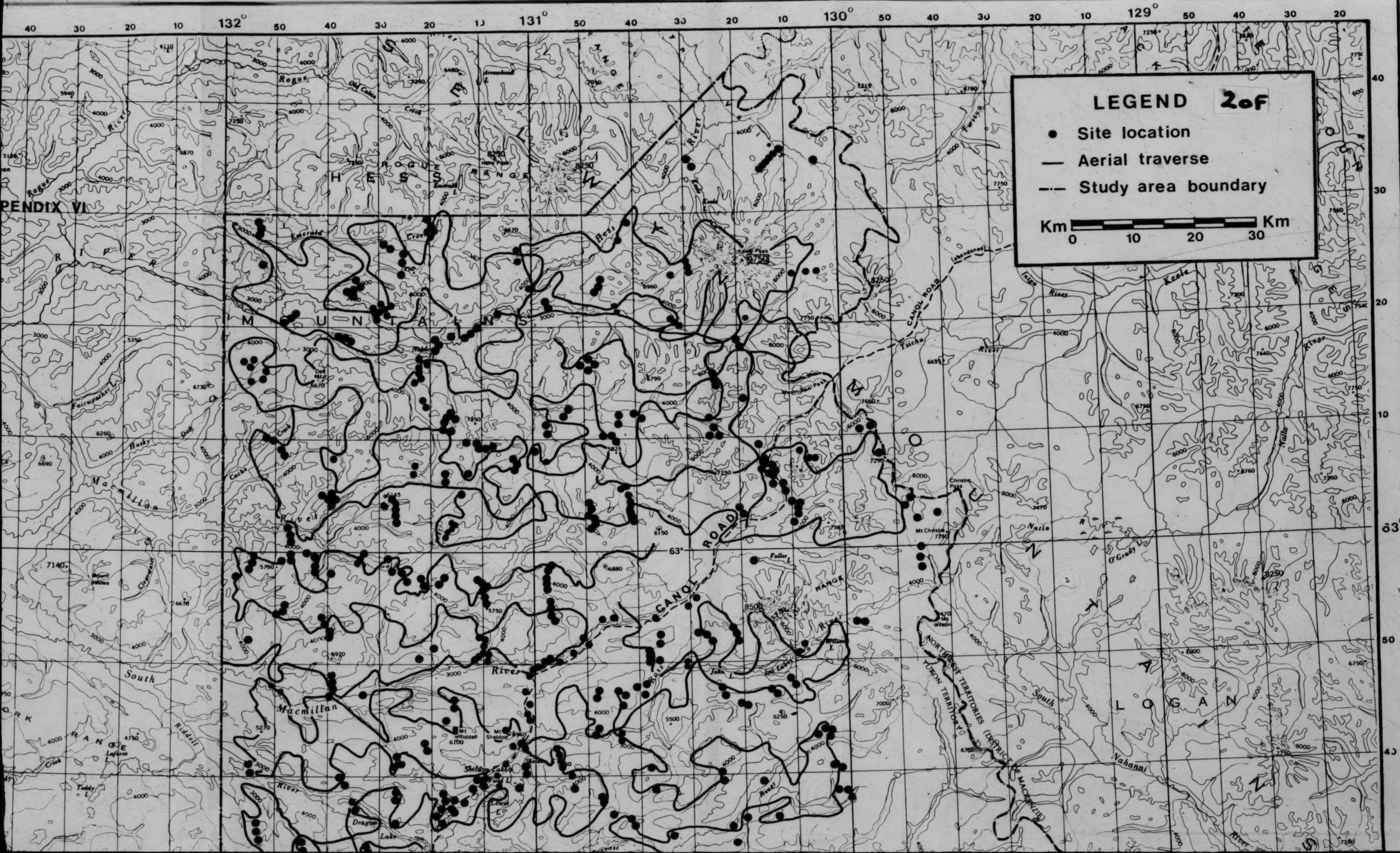
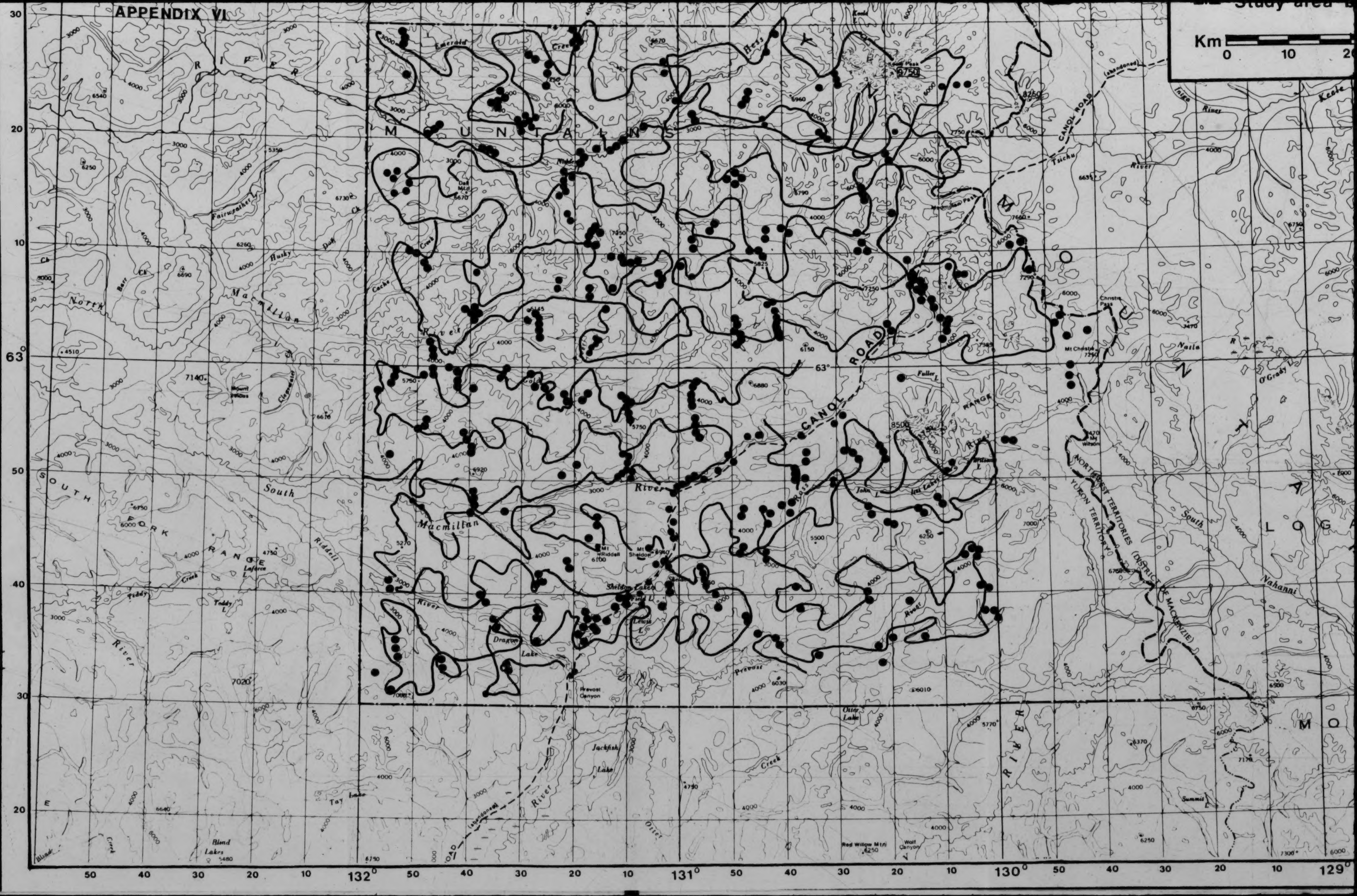
● Site location
— Aerial traverse
-·- Study area boundary
Km 0 10 20 30
133°
132°
131°
130°
129°
63°
HESS MOUNTAINS
ROGUE RANGE
SELWYN
MACKENZIE MOUNTAINS
LOGAN
SOUTH FORK RANGE
Rogue River
Macmillan River
South Macmillan River
North Macmillan River
Hess River
Tsichu River
Inga River
Keele
Nahanni
CANOL ROAD
(abandoned)
Sheldon Lake
Lewis L
Dragon Lake
Mt Riddell 6100
Mt Sheldon
Fuller L
Mt Christie
Christie Pass
Mt Wilson
Pleasant Lake
Swan L
Emerald L
Arrowhead L
Fairweather
Husky
Dolf Ck
Cache Creek
Teddy L
Laforce L
John L
Jeff Lakes
O'Grady L
NORTHWEST TERRITORIES (DISTRICT OF MACKENZIE)
YUKON TERRITORY

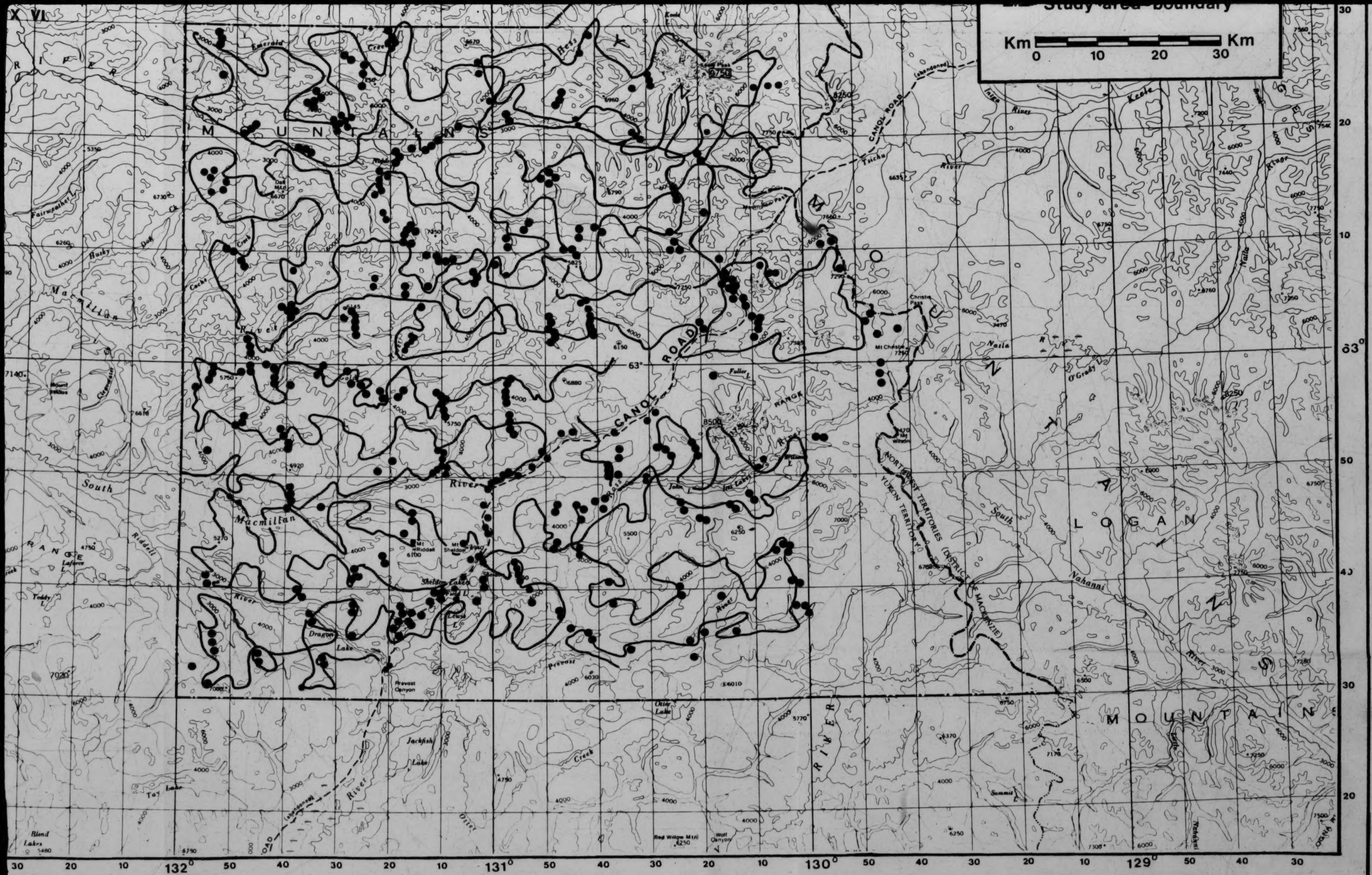

PENDIX VI
LEGEND
2oF
● Site location
— Aerial traverse
-·- Study area boundary
Km 0 10 20 30 Km
132°
131°
130°
129°
63°
HESS MOUNTAINS
ROGUE RANGE
CANOL ROAD
LOGAN MOUNTAINS
Macmillan River
South Macmillan
Rogue River
Hess River
Ross River
Keele Peak 9750
Fuller L.
Sheldon Lake
Dragon Lake
Mt Riddell
Mt Sheldon
Mt Christie
Christie Pass
Macmillan Pass
Tsichu River
Keele River
South Nahanni River
NORTHWEST TERRITORIES (DISTRICT OF MACKENZIE)
YUKON TERRITORY

APPENDIX VI



Study area
Km 0 10 20
MOUNTAINS
RIVER
North Macmillan River
South Macmillan River
SOUTH FORK RANGE
CANOL ROAD
Emerald Creek
Hess
Keele Peak 9750
Fairweather Ck
Husky Dog
Barr Ck
Cache Creek
Riddell
Teddy L
Laforce L
Mt Riddell 6100
Mt Sheldon 6940
Sheldon Lake
Lewis L
Dragon Lake
Prevost Canyon
Jackfish Lake
Otter Lake
Tay Lake
Blind Lakes
Red Willow Mtn 6250
Wolf Canyon
Fuller L
Mt Christie 7250
Christie Pass
Mt Wilson
Tsichu River
Intga River
Keele
Natla R
O'Grady L
Nahanni
South
Summit L
NORTHWEST TERRITORIES (DISTRICT OF MACKENZIE)
YUKON TERRITORY
LOGAN
MO
RANGE
63°
132° 131° 130° 129°
50 40 30 20 10
30 20 10 63° 50 40 30 20

3of


X VI
Study area boundary
Km 0 10 20 30 Km
MOUNTAINS
MOUNTAINS
LOGAN MOUNTAINS
RIVER
Macmillan River
South Macmillan River
Emerald Creek
Hess
Fairweather
Husky Dog
Cache Creek
CANOL ROAD
CANOL ROAD (abandoned)
Inlge River
Keele
Tsichu River
Keele Peak 9750
Christie Pass
Mt Christie 7290
Nalta R
O'Grady L
Fuller L
RANGE
Ross River
John L
Jest Lakes
Mt Riddell 6100
Mt Sheldon 6940
Sheldon Lake
Lewis L
Dragon Lake
Prevost
Prevost Canyon
Riddell
RANGE
Laforce L
Teddy L
NORTHWEST TERRITORIES (DISTRICT OF MACKENZIE)
YUKON TERRITORY
South Nahanni River
Otter Lake
Jackfish Lake
Tay Lake
Blind Lakes
RIVER
Creek
Red Willow Mtn
Wolf Canyon
Summit L
63°
63°
132°
131°
130°
129°
30 20 10 50 40 30 20 10 50 40 30 20 10 50 40 30 20 10 50 40 30
30 20 10 63° 50 40 30 20

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